Terraforming:
The Future & Adventure of Human Civilization

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"Men are weak now, and yet they transform the Earth's surface. In millions of years their might will increase to the extent that they will change the surface of the Earth, its oceans, the atmosphere, and themselves. They will control the climate and the Solar System just as they control the Earth. They will travel beyond the limits of our planetary system; they will reach other Suns..."

-Konstantin Tsiolkovsky

Preface

Uncontrolled human interference in natures work has resulted in environmental pollution and contamination, origin of virulent species of microorganisms and increased CO2 concentration in atmosphere and ocean water. We have consumed most of Earth's Natural Resources.

The human activity has caused the extinction of vast number of species on the planet. The changed atmospheric and environmental condition of the planet is threatening the existence of humans on the planet. Apart from extinction events and abrupt environmental changes, celestial events can also endanger the existence of humans on Earth. Close encounter of our solar system with another star, path of solar system passing through a nebula, Possible Collision of an Asteroids on earth, Solar Storms and Geomagnetic Reversal of Earth can bring an end to the Human era.

In case we fail to avoid or defend any of the above said events we can leave earth and settle on another planet. Terraforming is the method of creating habitable world for humans. It will be a new beginning, not to repeat the mistakes we did on earth.

I tried to formulate solutions in as many possible ways, towards problems associated with Extraterrestrial settlement. The major problem, I faced was to assume the variable set of environmental conditions on alien planets, to which we have never been to. I had to come up with minimum environmental requirement for human settlement under variable atmospheric composition, pressure, incident sunlight and availability of water for humans on a temporary or permanent settlement.

My research started towards the end of 2011. It took me nearly four years to gather all the required information and solutions for the problems of Extraterrestrial settlement. The process of improvement in techniques and research will continue until Humans settle on Mars, Venus and beyond.

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Part-1: Introduction

Chapter-1
Terraforming

On a barren planet originated the first seed of life “DNA”. With its appearance which possibly had come from a distant planet, hiding inside a cocoon of asteroid or formed right here on Earth by the interaction of organic soup and atmospheric electrical discharge, however it started spreading on the planet.

Though the order of evolution is too long we can simply tell: Life originated 3.6 billion years as Single Cell Prokaryotes, which evolved to single cell eukaryotes, the evolution process continued to Multicellular organisms, Bilaterians, Fish, Amphibians, Reptiles, Mammals, Birds, the Primates, last came in order the Humans.

The organisms living on the surface, atmosphere, oceans and subsurface habitats of the planet not only consumed their energy needs from the planet, but also interfered in its natural processes. For their energy requirements some of them depended on sunlight (Phototrophic), some on Oxidation-Reduction of inorganic or organic compounds (Chemotrophic), some used carbon dioxide as main carbon source (Heterotrophic) and some used organic carbon (Photoautotrophic) or carbon dioxide (Photoheterotrophic) etc.

In the primitive atmosphere of Earth, oxygen was formed by dissociation of surficial water vapour by solar radiation. Due to absence of ozone layer, sun’s ultraviolet radiation broke water molecules to Hydrogen (H_2) and Oxygen (O_2). Lighter Hydrogen gas escaped to space leaving Earth’s Atmosphere enriched with oxygen. This process became self-regulatory after some time, called the Urey’s Effect. But by this process very small amount of oxygen was produced in the atmosphere. Concentration of oxygen increased in the atmosphere due to appearance of phytoplankton, a microscopic species of Ocean or Fresh water dwelling organisms characterized by presence of chlorophyll within their cells which appeared for the first time on earth during this period. The organisms released necessary Oxygen to the atmosphere in the expense of CO_2 and H_2O, as the by-product of photosynthesis process. We can say, life since its origin has effected earth and its environment, as a result the environmental conditions on the planet have been altering.

White Cliffs of Dover in Britain was formed by Coccolithophores, whose skeletal remains sank to the bottom of the ocean during the Cretaceous Period, 65 million years ago. Coccolithophores are unicellular, eukaryotic phytoplankton (algae).

Each of them is enclosed with its own collection of Coccoliths, which forms its exoskeleton. The primary constituent of Coccoliths is calcium carbonate, or chalk.

Coral reefs can be found in many coastal regions all around the world. The Great Barrier Reef of Australia is one of them. Coral reefs are colonies of tiny animals found in marine waters, the Coral polyps. Coral reefs are the most diverse ecosystems on Earth. Most of the coral reefs are built from stony corals. Their colonies are made from calcium carbonate secreted by the Corals polyps. They can live in both temperate and tropical regions i.e. they are found near about 30deg North latitude to 30deg south latitude. From current polar expeditions, it has been found that few species of coral polyps can colonise even under ice sheets. We can see around and find organisms changing the planet's natural habitat by their activity. Apart other organisms' humans have played a major role in changing Earth's environment.

Human activity has degraded the natural habitat of organisms, which is visible in their confinement of habitat and extinction. The rapid loss of species we are seeing today is estimated to be between 1,000 times higher than the natural extinction rate. It is calculated that between 0.01 and 0.1% of all species will become extinct each year under normal conditions. With humans interference this rate can be much higher. Unlike any mass extinction events of geological history, the current extinction is brought by humans. Among the 44,838 species assessed worldwide using the IUCN Red List criteria, 905 are extinct and 16,928 are listed as threatened to be extinct. Millions of species still need to be assessed to know their status. As a result, the numbers of extinct and threatened species are definitely much higher than the current estimate.

The Humans are the peak consumers of nature. The modern era has brought with it, the mega engines and to power them we harvested Fossil Fuels and Hydro power. Due to unrestricted use of fossil fuels, industrial waste discharge, air, water and environmental pollution we are interfering in the natural processes of our planet. Humans are affecting and modifying the atmospheric and climatic parameters of Earth.

So the planet is changing and we are changing it. But the changes which have taken place on the planet naturally were unplanned and coincident. But if we attempt to change the planetary habitat knowingly with proper scientific approach for making it suitable for human habitation, is known as Planetary Engineering. For the case of other planets, Terraforming is the controlled modification of a region of the planet or whole of it, to make it habitable for Humans.

The aim Terraforming is to transform a specific region or the whole of the planet, making it habitable for human, by reproducing earth like environment.

But why is it necessary?

❑Since the arrival of Humans they are affecting and changing the Earth's environment. But more to that Earth is changing by itself. Earth changes, with it changes its climate, Atmosphere and Geological conditions. Like a living organism earth had been through various stages of climatic, crustal and planetary changes. Nearly 4.6 billion years ago it was a hot molten mass which gradually cooled down to a crust, mantle and core covered from outside with hydrosphere and atmosphere. For a period it was covered with water. It has been through many Ice ages. Also Earth receives variable amount of solar radiation which affects its climate. Earth has been through very cold periods during which its surface was covered with 100 meters of ice. According to Geoscientists this may be due to variation in incident solar radiation on earth or solar system was passing through a Nebula whose dust and gaseous clouds had obstructed the path between Sun and Earth.

❑Earth is protected from the harmful solar radiations, the solar wind, by the presence of its Planetary Magnetic Field. The solar wind consists of charged particles like proton and electron. Though the Particles are very small size, but they come with enormous amount of energy, and have the capacity to blow away the entire atmosphere of a planet. That is how Mars lost its atmosphere. Mars is like Earth, in many aspects had earth like surface environment. 4 billion years ago Mars had a liquid hydrosphere and atmosphere, the planet may have sustained living organisms. But as the core of the planet stopped generating Planetary Magnetic Field, the atmosphere was blown away by solar wind. Due to low surface pressure, all the liquid water on the surface of the planet was evaporated and dissipated to space. Now on Mars, water only exists as subsurface aquifers and polar ice caps. There may be possibility of life. So if the magnetism of Earth's core is lost this will bring human civilisation and all life forms to extinction.

❑Earth's magnetic field is generated by molten Iron-Nickel core. As a result Earth behaves like a bar magnet aligned N-S to Earth's N-S Geographic rotation axis. But according to scientists it not only weakens with time, it changes its orientation at certain intervals. This process is known as Magnetic reversal. This takes place in every 10000 to 1 million years. It has not taken place since a long time so there is a possibility of Magnetic reversal in near future. But the actual problem is before every reversal magnetic poles start to weaken. Then number of Magnetic North and South poles appear, which then move towards equator and finally North Pole turns to South and vice versa. During this period magnetic field of earth gets weakened and due to multiple number of magnetic poles, solar wind gets easily to the earth's surface. During this period one Coronal mass ejection (fast-moving bursts of plasma) can end all the life forms on Earth surface. It will not only blow away Earth's atmosphere, but also deform Earth's magnetic field for ever.

❑Solar system consists of Planets, their Satellites, Comets, Asteroids and Meteorites. Some of these Comets, Asteroids and Meteorites move closer to Earth during their rotation around Sun. These objects are known as near earth objects. These may collide with Earth any time. Every minute some of these fall on Earth, but before they reach the surface they either burn to dust or are burnt to so small size that they do not pose any harm to life on earth. But scientists have detected much large size near Earth objects which has the capacity to push human civilisation to Stone Age or end them forever. According to some scientists towards the end of Cretaceous Period, 66 million years ago, asteroid impact was the reason of Dinosaurs extinction. This has happened before and this can happen again.

❑From the study of fossils, we know that, life sustains on earth by evolution, which begins by appearance of new species to cope with the changed environmental condition. The newly appeared species adapts to the environment and flourishes. The species may spread and dominate the planet for an appreciable time. When changes in environment turn extreme, i.e. the new species can no more sustain in Earth's altered environment, it goes extinct. But in the process a new species takes its place, so they say life finds a way. In past the Neanderthals went extinct in conflicts and competition with Homo Sapiens. May be in future evolution will take a next step and force humans to leave Earth.

❑The greatest threat to Earth is the Humans themselves. After the discovery of Nuclear power we are capable of destroying everything we have created till now. Many philosophers predict that World War-III will be the end of the World. Except that global warming and environmental pollution is making Earth more inhospitable for organisms.

❑From history we have learnt that every civilisation passes through three stages. They form a strong social order and then develop, after a certain period the development stops, then they destroy themselves. This is the story of every developed civilization on Earth.

Above are the few reasons to explain, why terraforming is necessary for the future of human civilization. If any time in near or distant future Earth becomes inhospitable place for humans due to above said or any other reasons by the knowledge of Terraforming Humans can have a second chance. It may be the tool of our survival.

There are eight planets, many dwarf planets and satellites in our solar system which can be used as a place for testing human knowledge and capacity to create new worlds. Among the solar systems, planets and satellites very few can be made habitable for humans, because humans require a specific set of climatic and terrestrial condition to sustain. For finding Terraformable planets we must look at the members of solar system which might sustain life. From the data collected from recent space missions Mars, some satellites of Jupiter and Saturn may have primitive life forms.

Among the solar system members, some can be considered for Terraforming, while others will provide the necessary tools for the same, which will be described in detail later.

Solar system objects arranged in space, away from sun, as we move outward:

Planet	**Satellite**	**Dwarf Planet**	**Asteroid Belt**	Major Solar System objects as we move away from sun
Mercury				
Venus				
Earth	Moon			
Mars	Phobos			
	Deimos			
		Ceres		
			Asteroid belt	
Jupiter	Io			
	Europa			
	Ganymede			
	Callisto			
	Metis			
	Adrastea			
	Amalthea			
	Thebe			
Saturn	Titan			
	Rhea			
Uranus	Miranda			
	Ariel			
	Umbriel			
	Titania			
	Oberon			
Neptune	Triton			
			Kuiper belt	
		Orcus		

Pluto		
2002 MS4		
Salacia		
Haumea		
Quaoar		
Makemake		
	Scattered Disc	
2007 OR10		
Eris		
Sedna		
	Oort Cloud	

Table 1.1, Solar System Planets

Chapter-2
Basic Requirements for Terraforming

All the organisms living on the Planet Earth are the part of ecosystem known as biosphere. Biosphere is formed by the interaction and intersection of Hydrosphere (Oceans, Rivers and all water bodies), Lithosphere (solid outer shell of earth) and Atmosphere (composed of gases in many layers attached to surface of earth by force gravity).

How life originated on Earth from non-living chemicals is a mystery. But we know its basic building block is Carbon. The most unique character of carbon atoms is to form long chain polymorphs with other elements. These long carbon chain polymorphs formed on the primordial earth were the protein molecules which were the most primitive and basic life forms. These carbon compounds are composed of 6 basic elements C, H, N, O, P and S. This is the composition of every living organism on Earth.

Though life originated in a toxic, highly acidic and carbon dioxide rich environment as unicellular organisms, it evolved to higher forms with time and gave birth to most complex and intelligent life forms.

It is difficult to confine life to certain physical and chemical parameters. Because it is not confined by any set of climatic or environmental conditions. Scientists have spotted life above polar ice caps and below them, deep ocean surface, near volcanic vents, in tropical deserts and rain forests. It is possible that the organism's population density may vary from place to place, but they all bear the same seed of life and the characteristic of adaptation, each of them is unique and amazing. The diversity of life and food chain in different habitats is exceptional.

But Humans require a specific atmospheric, climate and environmental condition to sustain their life. Humans require five basic elements

1. Protection from solar and cosmic radiation
2. Atmospheric condition
3. Necessary gravity
4. Water or Ice
5. Source of energy

1. Protection from solar and cosmic radiation (Magnetosphere)

For a solar system its Star is the basic source of energy for all of its planets. Our Sun provides us with energy for photosynthesis which is the basic source of energy for all living organisms. Sunlight takes about 8.3 minutes to reach earth's surface. Sun radiates Infrared, Visible, ultraviolet light, X-rays and Radio waves. Additional to this sun emits neutrinos and charged particles. It emits stream of electrons and protons known as solar wind released from the upper atmosphere of the Sun.

These charged particles come with enormous amount of energy, that they can blow away the whole atmosphere of a planet. This is how Mars lost its atmosphere. 4 Billion years ago Mars had an active magnetosphere. It had a thick atmosphere, liquid hydrosphere and may have sustained life. But then a moon sized asteroid collided with Mars, due to the shock waves generated by impact, its planetary magnetic field was lost and magnetosphere disappeared. With no magnetic field around the planet, Mars' atmosphere started to be stripped away by Solar Wind. With loss of atmosphere Mars' surface pressure decreased which caused liquid water to disappear from surface.

So the magnetic field of Earth is the only thing standing between Earth and Solar Wind. Earth's Magnetic field, similar to a bar magnet whose North is directed to geographic south and South to geographic North, is generated by its core. The average magnetic field in the Earth's outer core is nearly 25 Gauss and on surface between 0.25 to 0.65 Gauss.

The region where the solar wind is deflected by Earth's magnetic field is known as magnetosphere. Magnetosphere not only deflects Solar Wind, but also it deflects cosmic radiation, high-energy charged particles coming from outside the Solar system. As solar wind is a continuous stream of particles it creates a pressure which is opposed by earth's magnetosphere. The Magnetopause is an area where the pressures balance, is the boundary of the magnetosphere.

The space radiations cause direct damage to Cell Chromosomes and un-natural reaction of exposed tissues. Both short and long term effect of exposure to cosmic radiation are likely to pose significant neurological health risks to human in long-term space travel. Considerable exposure to high energy heavy ions as well as protons, electrons and secondary radiations may result Carcinogenesis.

So for humans to live both in space habitation or other planets they need to shield themselves from solar wind and cosmic radiations.

2. Atmospheric condition (Pressure, Temperature and Composition)

In the early stage of earth’s origin its atmospheric condition was much different from that of today’s. The primary planetary atmosphere was hot dense with composition of water vapour, methane and ammonia. As the earth cooled its atmospheric composition changed to Nitrogen, carbon monoxide and dioxide with inert gasses. Then started the third stage, the Great Oxygenation Event, since then the atmosphere has evolved and gradually turned to present composition. From an early planetary atmosphere to present composition, surface temperature and pressure has also changed.

By volume, dry air contains 78.09% Nitrogen, 20.95% Oxygen, 0.93% Argon, 0.039% Carbon Dioxide, and small amounts of other gases. Air also contains a variable amount of water vapour, on average around 1%. The pressure and temperature varies from place to place. Pressure at the sea level is 101.325 kPa (MSL) also known as 1bar and mean surface temperature 287.2 K which varies from place to place. As this is the standard scale for atmosphere in which humans can live with variation of these parameters within acceptable limits.

The parameters of atmosphere composition, Pressure and Temperature should be within reasonable limits to make it breathable for humans. So to live on another planet we have to create the same atmospheric conditions like Earth.

3. Necessary gravity

Gravity is one of the four fundamental forces of nature, along with electromagnetism, and the nuclear strong and weak force. Gravitation is a force of attraction that acts between and on all physical objects with mass. It is represented by ‘g’ and termed as acceleration due to gravity. On the surface of Earth acceleration due to gravity is $g = 9.8\ m/s^2$.

The gravitational acceleration experienced at any point around a larger mass M of Radius r, represented by:

$g=-GM\hat{r}/r^2$

Where G is the gravitational constant

$\hat{r}$ is a unit vector directed from the large mass to the smaller mass

The negative sign indicates that the force is an attractive force

Humans are well-adapted to the physical conditions at the surface of the Earth, constant gravitational force acting on body. The most common problem experienced by humans in the initial hours of weightlessness is known as space adaptation syndrome or SAS, commonly referred to as space sickness. Symptoms of SAS include nausea and vomiting, vertigo, headaches and lethargy. The most significant adverse effects of long-term weightlessness are reduced muscle mass, strength and performance, deterioration of the skeleton, balance disorders, slowing of the cardiovascular system, decreased production of red blood cells, and weakening of the immune system.

So to live on a planet with value of gravitational force lower or higher that earth will be difficult for humans, which is to be solved with help of modern science and technology.

4. Water or Ice

Water is regarded as most essential element for life in universe. It is a chemical compound with the composition of one oxygen and two hydrogen atoms that are connected by covalent bonds. Water is a liquid at standard ambient temperature and pressure, but it often co-exists on Earth with its solid state, ice, and gaseous state, steam (water vapour).

Liquid Water covers 71% of the Earth's surface. On Earth, 96.5% of the planet's water is found in seas and oceans the rest is fresh water. Out of all fresh water, over 68 percent is in form of ice and glaciers, 30 percent is trapped in form of ground water. The rest is distributed in the air as water vapour, in rivers, ponds and lakes, in the ground as soil moisture and as biological water. Rivers are the source of most of the fresh surface water people use, which only constitute about 0.0002 percent of total water.

Human body constitutes nearly 60% water. Every organism requires water for its day to day cellular activity. Earliest life forms appeared in large Oceans which then covered the Earth. For intake of chemicals and production of energy every living cell requires water. That’s why it is called Universal Solvent.

So to live on any planet Humans will require huge volume of water to sustain life. If not available on the planet in any manner we have to bring water for our habitation. Or we have to find other source of water.

5. Energy

No organism can carry out its day to day activity without source of energy. No different from others, Humans also require a power source to work with their machines. For Terraforming we will need huge and unending source of energy.

Chapter-3

Classification of Terraformable Planets

As per the decision of IAU (International Astronomical Union) definition of a planet within the Solar System is:

A celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.

In our search for Solar and Extra-Solar planets, we may encounter many planets around distant stars. For identifying a celestial body as Planet, we should to have a proper set of parameters. An exoplanet should be:

A celestial body that (a) is in orbit around a Star, (b) is non luminous and has no thermonuclear fusion of deuterium going inside its core currently or previously, (c) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit is a Planet.

There are many solar system members which are Terraformable. For some we can use the methodologies of terraforming, but for some it will take very long time period and huge amount of energy, that instead of terraforming we should build habitable domes on those planets and use them as temporary or emergency settlement.

Planets close to Sun are characterized by extreme surficial temperature, but as we move away the temperature drops and planets become cooler. Again planets close to Sun are mostly rocky and as we move away we encounter gas giants of solar system. But there is a zone where planets Temperature is not too high or low, has a well-defined atmosphere and due to availability of other necessary constituents, possibility of finding habitable planets is more.

Circumstellar habitable zone (CHZ) known as the Goldilocks zone is the region around a star within which planets with enough mass to generate sufficient atmospheric pressure can support liquid water at their surfaces. On earth, water is the most important ingredient for organic life forms. It is considered that planets inside CHZ are able to sustain life due to availability of liquid water.

The planets in this zone will have enough surface gravity to hold an atmosphere, producing enough atmospheric pressure to sustain liquid water on their surface and may have magnetosphere to protect surface environment from solar radiation. Mostly rocky planets are found in this zone, as the lighter elements of solar system are blown away by sun's radiation pressure during the early formation of solar system. So Terraforming can be easily applied to Rocky planets. It is difficult to transform gas giants to habitable planets because of their large size, variable composition and very small rocky core.

But in our search for habitable worlds and terraforming planets we will also encounter Moons and Dwarf planets which can be made habitable so we have to broaden our search criteria. So a Terraformable planet is:

A Planet, Moon or Dwarf Planet which has one of the following parameters (a) Value of surface Gravity close to earth i.e. size of the planet is similar to Earth (b) Located around the star inside or close to the Circumstellar Habitable Zone (c) has surface or subsurface storage of water or ice (d) an atmosphere with composition similar to Earth, and can be Terraformed within limited time and energy spent.

Terraforming is the creation of habitable world for humans to live, grow and evolve on Solar and Extra Solar planets. Considering the basic parameters required for Humans to live on a planet, we can estimate planets favourability for Terraforming. The parameters used for the following purpose are:

1. Necessary Gravity
2. Magnetic field to protect from Cosmic Radiation
3. Breathable Air
4. Surface water or Surface/Subsurface Ice

If the planet is not Terraformable we still can establish settlement on the planet by building habitable domes. These habitable domes contain all the necessary elements for human survival and provide an earth like environment. This process of controlling and changing a small part of a planets to make it habitable is known as Para-Terraforming. As per our requirement we can use our technology to select the method of Terraforming, for the target planet.

For easier understanding and study, basing on above said parameters Terraformable rocky planets can be divided into following categories:

Type-I	**Smaller size deserted planets:** Planets of size similar to Moon of Our Earth and Dwarf Planet Pluto. These planets produce very low gravity, therefore contain thin or residual atmosphere composed of Hydrogen and Helium, little amount of water stored in from of ice on its surface craters brought by impact events.
Type-II	**Smaller and medium size planets with Ice stored in Polar regions:** Planets of size similar to Mars and some Galilean moons Europa, Ganymede and Callisto. These planets have low surface gravity but contain huge reserve of usable Ice stored in Polar, Subsurface regions. The atmosphere of these planets are enriched by the surface components but slowly dissipates into space.
Type-III	**Earth size planets with variable atmospheric composition and water or Ice stored in Polar or subsurface regions.** Earth Sized rocky Planets with an atmosphere, appreciable reserve of Water. The planets interior is well differentiated, but the Geodynamo may not produce magnetic field.
Type-IV	**Earth Size planets with variable atmospheric composition** Earth Sized rocky Planets with an atmosphere, without any availability of ice or water and extreme surface conditions (volcanic or frozen planet). The planets interior is well differentiated but the Geodynamo may not produce magnetic field.
Type-V	**Giant Rocky Planets with dense atmosphere, water and ice stored in Polar or subsurface regions.** Planets of size larger than earth, capable of holding a dense atmosphere because of their strong gravity, contains huge volume of water or ice. Some of these planets are water worlds.

Part-2: Paraterraforming

Chapter-4
Giant Magnetic Field

Solar wind is a stream of charged particles released from the upper atmosphere of the Sun, mostly consisting of high-energy electrons and protons. The particles have enough energy to blow away Earth's atmosphere. Not only planetary atmosphere can be affected by the solar wind, but also it damages organisms' DNA causing irreversible defects. Due to bombardment of high-energy particles, the organic cell compounds start to dissociate, which is resulted in form of deformity or Cancer.

However, these harmful radiations could not harm the life on earth, as it is protected by the presence of its Magnetosphere. Magnetosphere deflects the incoming solar wind particles and keeps the Earth's surface untouched. Earth's magnetic field is generated by liquid Iron-Nickel core.

From geophysical evidences, it is concluded, that Earth's interior is divided into 3 concentric layers. The outer part of the planet, Crust, consists of Continental and Oceanic Crust is 30 to 70 km thick. The Mantle extends below the crust up to 2900 km depth, and below the Mantle, the Core.

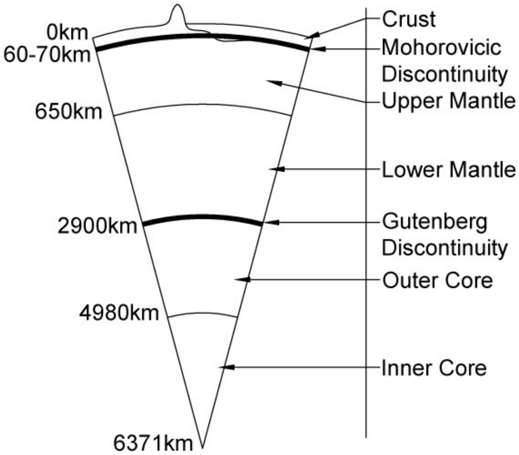


Figure-4.1, Interior of Earth

The Core is divided into two parts Solid Inner Core and Liquid Outer Core. The outer core is in liquid state extending to 4980km depth below the Mantle, while the inner core is in solid state and extends to depth 6371km centre of Earth. Both outer and inner core are composed primarily of iron and nickel.

Earths Outer core is in liquid state while the inner core is in solid state at a very high pressure and temperature. On the other side Mantle, which is at comparatively much lower temperature and pressure is at the neighbourhood. So due to the temperature difference, heat flows from the outer core towards mantle, as a result convection currents are set inside the liquid outer core. From indirect evidences and experiments, the theory is strengthened that Earth's magnetic field is generated by the electric currents flowing inside the liquid metal core. Due to convection current and temperature difference, the rate of movement of the conducting Fe-Ni fluid at the junction between Mantle and outer Core will vary from the inner deeper parts. This difference generates electric current and associated magnetic field. This hypothesis explaining the origin of earth’s magnetic field, is known as Dynamo Hypothesis.

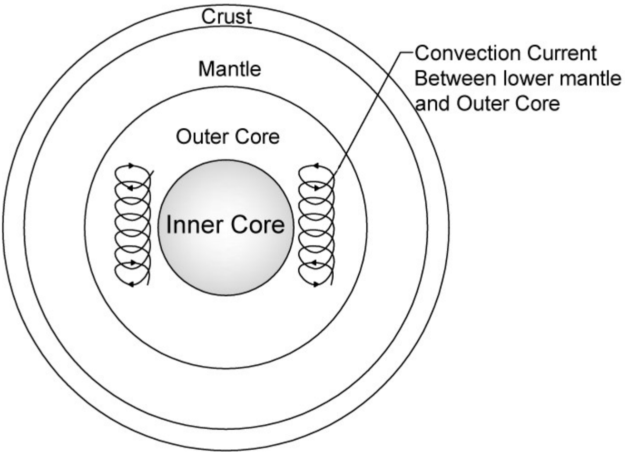


Figure-4.2, Geodynamo of Earth

For planets like Mars, where the core of the planet is no more generating magnetism or the planetary Geodynamo has stopped to work, resulting a weak or trace Magnetosphere. This leaves the planet’s atmosphere much vulnerable to solar wind. The atmosphere of the planet is slowly striped away by solar wind and radiation, leaving a low pressure environment on its surface. Due to low atmospheric pressure, boiling point of water decreases causing absence of life giving liquid water on the planet’s surface.

There are many theories explaining loss of Mars’ magnetic field. Some say reasons may be a large sized asteroid impact or solidification of the liquid iron core due to cooling. Some believe it is because of the smaller planetary size, for which planet was not able to segregate enough heat during its formation to keep its core in liquid state for a longer period.

Currently scientists have found many giant planets a few times heavier than Earth with enough gravity and water on its surface to sustain life. But do those planets have their own magnetosphere?

If we accept the Dynamo mechanism is the only way of generating planetary magnetism, we can say that the planets composition and internal structure has to be similar to Earth to generate Magnetic field. But even a planet is rocky or terrestrial and inside the habitable zone, still it may not have its own magnetic field.

It is possible, due to larger size i.e. its mass is much higher than earth and due to increased pressure towards the core of the planet outer core will remain in solid state. Without convection currents in the outer core there will be no magnetic field around the planet, resulting absence of magnetosphere around the planet to protect it from solar and cosmic radiation. This explains the importance of magnetosphere around a planet for survival of organic life on it.

For Terraforming planets with enough gravity to hold an atmosphere and availability of water in liquid or Ice form we will require a shield from the solar and cosmic radiation. So if the planet does not have its own magnetic field humans have to create an artificial magnetosphere. Though it is not possible to build an Earth sized magnet we can build artificial magnetosphere for small habitations.

Solar wind contains mostly electrons and protons. Cosmic radiation consists of much variety of particles. Of all the particles in cosmic radiation nearly 90% of them are Protons, 1% Electrons, 9% Alpha Particles and a very small amount of nuclei of heavier elements.

Alpha Particles can be shielded by thick sheet of Lead and other metals. As Alpha Particles and nuclei of heavier elements are larger sized (compared to electrons and protons) and collide with much low velocity, so they can be overcome by the same magnetic field strength used to deflect high energy protons and electrons. So if we can overcome high energy Electrons and Protons, then others will take care of themselves.

A standard habitation can be of variable size on any solar or extra solar planet depending on our requirement. Let’s consider the length of a standard habitation be 500m long and 100m wide of living space inside it. The structure will be a tunnel shaped multi storied habitation.

The tunnel should be surrounded with number of electromagnets. The electromagnets are powered by the Solar Panels, placed near the habitation, this will provide with the necessary energy for operating the electromagnets.

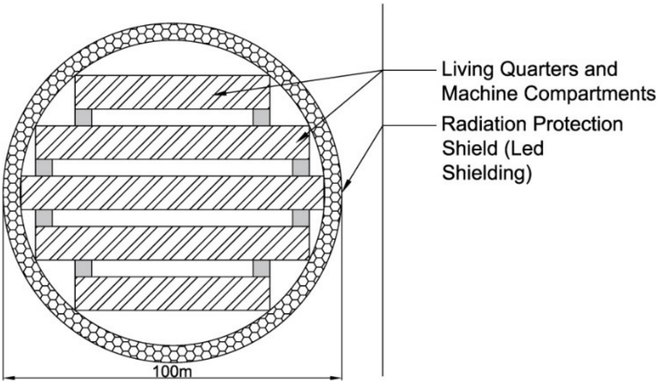


Figure-4.3, Cross Section view of Habitation Tunnel

Every charged particle has a mass and a charge, and it can be deflected in presence of strong magnetic field. If on the surface of the planet we can create strong enough magnetic field, the solar wind and cosmic radiations can be deflected before reaching the human habitation.

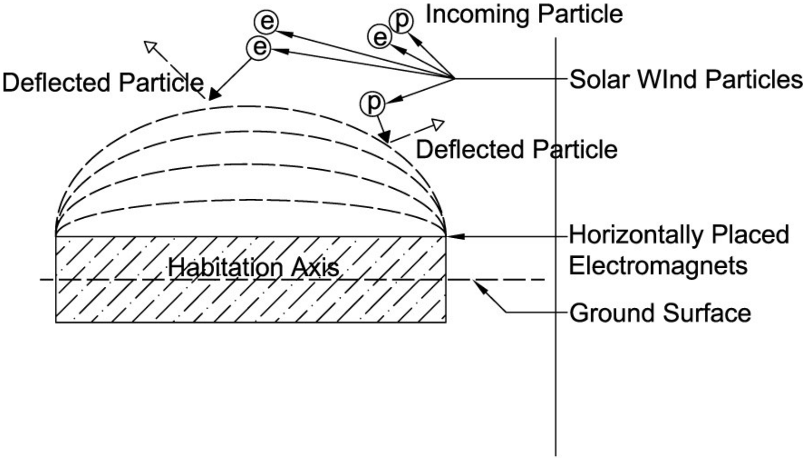


Figure-4.4, Deflection of Solar wind Particles by a Tunnels Magnetic field

For deflecting a charged particle we have to consider the forces acting on it inside a uniform electromagnetic field. Lorentz force is the force acting on a point charge in presence of an electromagnetic field. If a particle of charge q moves with velocity v in the presence of an electric field E and a magnetic field B, then it will experience a force.

$F=q\ (E + v \times B)$

For a planetary magnetic field force applied on charged particles of solar wind will be

$F=q\ v \times B$ (we consider the generated magnetic field only)

Knowing the q i.e. charge, v i.e. velocity of the charged particle we can calculate the intensity of magnetic field required to deflect a moving charged particle at certain distance in desired direction. If we can produce enough strong magnetic field it will deflect the incoming charged particles coming from space.

Force acting on a charged particle with charge q, inside a magnetic field B moving with a velocity v is F:

$F=q\ v\ B\ \text{Sin}\phi$

Φ being the angle between the direction of magnetic field and the velocity of the charged particle

Due to the force applied by the magnetic field on the charged particles, it will change its path i.e. its speed remains unchanged. The particles travel in a circular path, which depends on the charge and momentum of particles, and the instantaneous magnetic field. Therefore, the force applied by the magnetic field on the charged particle is equal to the centripetal force required to move the particle in a circular path.

I.e. because the magnetic force F supplies the centripetal force Fc, we have

$F=Fc$

$\Rightarrow F=m\ v^2/r$

$\Rightarrow q\ v\ B=m\ v^2/r$

$\Rightarrow r=q\ B/m\ v$

$\Rightarrow B=r\ m\ v/q$

Where, r is the radius of curved path followed a charged particle with mass m and charge q, moving at a speed v perpendicular to a magnetic field of strength B. If the velocity is not perpendicular to the magnetic field, then v is the component of the velocity perpendicular to the field. The component of the velocity parallel to the field is unaffected, since the magnetic force is zero for motion of particles parallel to the field.

So we need magnetic field strength B to deflect a charged particle of mass m, charge q and moving at a speed v perpendicular to the magnetic field.

Sun emits electrons and Protons in form of solar wind. The solar wind has a typical velocity of 750 km/s. as the electron and proton travel with same velocity, with equal and opposite charge, and proton has higher mass the magnetic field which can deflect proton can certainly deflect electron.

So the magnetic field intensity required for deflecting a solar wind particle i.e. Proton:

B=r m v/q

Where

m, Mass of Proton =1.672621777(74) $\times 10^{-27}$kg

q, Charge of Proton=1.602176565(35) $\times 10^{-19}$C

r, Radius of deflected path(Half of the length of habitation)=0.25km,

v, Velocity of the charged particle=750 km/s

So the magnetic field intensity:

B=r m v/q

$\Rightarrow$B= (0.25km X 1.672621777 X 10^{-27}kg X 750km/s)/1.602176565 X 10^{-19}C

$\Rightarrow$B= (0.25m X 1.672621777 X 10^{-27}kg X 750m/s X 10^{6})/1.602176565 X 10^{-19}C

$\Rightarrow$B= (0.25 X 1.672621777 X 10^{-21} X 750 X kg X m^2/s)/1.602176565 X 10^{-19}C

$\Rightarrow$B= (627.233166375 X 10^{-21} X kg X m^2/s)/1.602176565 X 10^{-19}C

$\Rightarrow$B=313.6165832 X 10^{-2} X kg X m^2/s X C

$\Rightarrow$B=195.7440834 kg X m^2/s X C

$\Rightarrow$B$\approx$2 kg X m^2/s X C

$\Rightarrow$B$\approx$2 tesla

So to deflect the solar wind particles we need nearly 2 tesla magnetic field intensity at the radius of the tunnel. Now to have the same intensity at 250 m radius i.e. 500m tunnel of the habitation we have to calculate the current required to generate such magnetic field.

From Biot-Savart's Law the magnetic field generated by a current carrying wire at distance r from the wire will be:

$B=\mu_0 I/2\pi r$

B is magnetic field intensity inside a hollow solenoid, carrying current I and μ_0 is the magnetic constant.

$B=\mu_0 I n$

n=number of turns per unit length (N/L i.e. N=Number of loops and L=Length of the solenoid

Let's take number of turns on the solenoid we are considering is N=50,000 i.e. n=100

If the solenoid is Iron core it will increase the Magnetic field strength many fold. In this case Magnetic field intensity inside the solenoid will be:

$B=k \mu_0 I n$

Where *k* is the 200,000 of pure Iron (99.95% pure)

But when we consider for magnetic field outside the solenoid the magnetic field strength decreases as the flux and permeability value decreases.

So the value of magnetic field strength outside a hollow solenoid will be:

$B= \mu_0 I N A/2 \pi z^3$

Where magnetic field strength of a finite solenoid at distance z from the centre axis of the solenoid is measured.

The value at same distance for an Iron core solenoid will be:

$B= k \mu_0 I N A/2 \pi z^3$

The arrangement will be placed on the surface of the planet. The planet may contain a thin or dense atmosphere, so ideal conditions we may consider $\mu_0= \mu=1.25663753 \times 10^{-6}$

$B= k \mu I N A/2 \pi z^3$

The solenoids are arranged outside the tunnel parallel to the alignment of the habitat. The magnetic field will be generated by the solenoid because of the current flowing through the coil. Hence the current required to produce the necessary magnetic field will be:

⇒$I= 2 B \pi z^3 / k \mu N A$

Where I=Current flowing through the solenoid

B=the Induced magnetic Field

z= distance from the centre axis of the solenoid

k=Relative Magnetic Permeability

μ= Magnetic Permeability of Air

N= Number of turns in the solenoid

A=Area of Cross section of the Solenoid

r= Radius of the Solenoid=2m

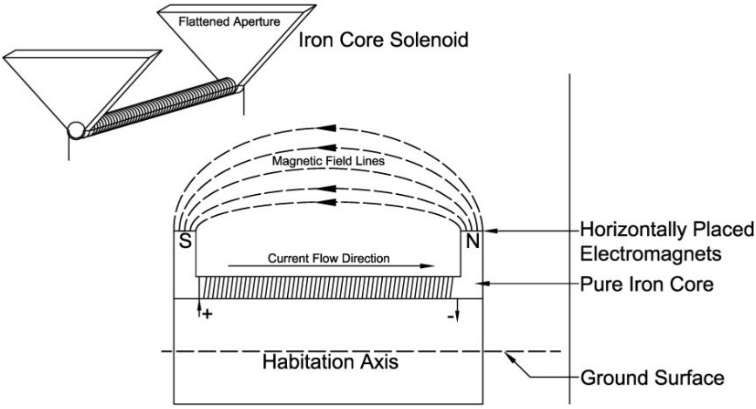


Figure-4.5, Iron Core Solenoid generating Magnetic Field to Deflect radiation

So:

⇒$I= 2 B \pi z^3 / k \mu N A$

⇒$I= 2 B z^3 / k \mu N r^2$

⇒$I= \{2 \times 2T \times (500)^3 \, m3\} / \{200{,}000 \times 1.25663753 \times 10^{-6} \times 50000 \times 4\}$

⇒I=9947.180234A

⇒I=9947.2 Amp

From the above calculations we have the strength of magnetic field required to deflect solar wind and the required current for generating the same. We can produce the required amount of electricity from the solar panels placed on both sides of the habitat or we can use any other source of energy like nuclear for powering the electromagnet.

According to Ohm's law:

$R=V/I$

Where I is the current through the conductor in amperes, V is the potential difference measured across the conductor in volts, and R is the resistance of the conductor in ohms.

$\Rightarrow V=RI=9947.2\ A\ X\ R$

$\Rightarrow R=\rho L/A$

Where L is the length of the conductor, measured in metres, A is the cross-sectional area of the conductor measured in square metres and ρ is the electrical resistivity (of the material, measured in ohm-metres (Ω·m).

Let electrical resistivity for standard Copper wire 1.68×10^{-8}

Where r is the radius of the solenoid and N is the number of turns.

L, the length of the conductor is:

$\Rightarrow L=2\ X\ \pi\ X\ r\ X\ N$

$\Rightarrow L=2\ X\ 3.143\ X\ 2\ X\ 50000$

$\Rightarrow L=628600m$

A, the cross-sectional area of the conductor is $A=\pi\ X\ r^2$

Radius of the wire let be 1cm.

$\Rightarrow A=\pi\ X\ r^2$

$\Rightarrow A=3.143\ X\ (0.01m)^2$

$\Rightarrow A=3.143\ X\ 10^{-4}\ m^2$

So the value of resistance, R is;

$\Rightarrow R=\rho L/A$

$\Rightarrow R=1.68\ X\ 10^{-8}\Omega\ X\ m\ X\ 628600m/\ 3.143\ X\ 10^{-4}\ m^2$

$\Rightarrow R=33.6\ \Omega$

$\Rightarrow V=R\ X\ I=33.6\ \Omega\ x\ 9947.2\ Amp=\ 334225.2559\ V$

I.e. if we pass current of 334.2 KV the desired magnetic field can be achieved.

Achieving the above voltage may be difficult. But to achieve the same we can use wire of available super conductors to generate the same magnetic field. That will reduce the resistance of the coil in turn decreasing the necessary voltage requirements.

From the above calculations we have the strength of magnetic field required to deflect solar wind and the required current for generating the same. We can produce the required amount of electricity from the solar panels placed on both sides of the habitat or we can use any other source of energy like nuclear for powering the electromagnet.

The habitation will be a hollow solenoid consisting of number of iron core solenoids symmetrically arranged at the wall of the Tunnel. A strong Magnetic field will be generated due to flow of electric current through the coils. Each electromagnet consists of an Iron core solenoid powered by the solar panels put on both sides. This arrangement will generate enough strong magnetic field as calculated above to deflect solar wind and cosmic radiation.

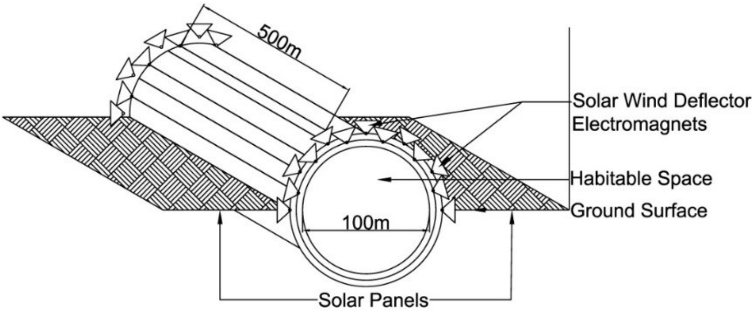


Figure-4.6, Model Habitation Magnetic field Generator

For planets with low or zero planetary magnetic fields we can use these arrangements for human settlement. These tunnels becoming fully operational will protect human habitation from cosmic radiation hazard and a way of settlement on uninhabited planet.

Chapter-5

Spider-Web Ozone

Life originated on earth nearly 4 billion years ago when the geological and atmospheric conditions were different. Early atmosphere of Earth was composed of Carbon Dioxide, Carbon Monoxide, Sulphur Dioxide, Ammonia, Methane, water vapour and Small amount of oxygen. Because of the photochemical dissociation of water vapour, hydrogen and oxygen gases were produced. With elevated production of Oxygen from water molecules, the concentration of oxygen increased in upper atmosphere within 80 to 100km height. At the upper atmosphere oxygen molecules started to break into free Oxygen absorbing energy from UV rays.

UV rays coming from Sun and outer space are harmful for living organisms and Humans on our planet. Ozone layer protects us from harmful solar radiation UV rays. Ozone layer is found mainly at the lower part of Stratosphere. It is a very rare atmospheric gas of in Earth's atmosphere of concentration only about 0.6 parts per million and less than ten parts per million in Ozone layer.

Ozone consists of 3 oxygen atoms with chemical formula O_3. When UV rays strike an ozone molecule, it absorbs the energy and splits into Oxygen molecule and one free oxygen. Then the free oxygen bonds to an oxygen molecule and forms ozone O_3. And this cycle repeats itself to maintain ozone level in ozone layer. Discontinuity in this cycle is caused by external interference.

Based on their wavelength UV rays are divided into 3 types: UV A (400–315 nm), B (315–280 nm) and C (280–100 nm). Extremely short or vacuum UV (10–100 nm) is screened out by nitrogen. UV-C is very harmful to all living things, is entirely screened out by a combination of Dioxygen and Ozone (100–200 and 200–280 nm) in the atmosphere. UV-B is absorbed by Ozone.

The ozone layer is very effective at screening out UV-B. Ozone is transparent to most UV-A, so most of this longer wavelength UV radiation reaches the surface.

The Chapman Model explains the ozone cycle, formation and destruction of ozone molecules from oxygen molecules:

Initiation:

$O_2+hv \rightarrow O+O$

(Planck's constant=h, Frequency=v, hv is the energy of a photon particle)

Propagation:

$O+O_2+M \rightarrow O_3+M$

(M is an arbitrary third body, which absorbs the extra heat generated from the exothermic reaction)

$O_3+hv \rightarrow O_2+O$

Termination:

$O+O_3 \rightarrow O_2+O_2$

$O+O+M \rightarrow O_2+M$

This mechanism clearly shows absorption of radiation by O_2 and O_3 from sunlight which leads to production of reactive oxygen which takes part in exothermic reaction of O_3 formation and destruction.

In the propagation process ($O_3+hv \rightarrow O_2+O$) absorbs UV wavelength ($210<\lambda<300$ nm) and breaks to Oxygen molecule and free Oxygen. Ozone layer protects organisms of the planet by absorbing harmful UV radiation.

When sun emits enough UV rays to penetrate Ozone layer i.e. the flux is so high that the ozone layer thins, therefore ozone oxygen ratio cannot be maintained. Human activity also has affected ozone cycle since last few decades. Chemical industry and many machines produce Halocarbon (Carbon, hydrogen, Bromine, Fluorine and Chlorine) such as Chlorofluorocarbons and Carbon tetrachloride and Methyl Chloroform which are major ozone depleting compounds. This has given rise to ozone holes through which harmful UV rays penetrate to earth’s atmosphere and reach planet’s surface.

During our travel by distance solar systems and galaxies we may find habitable planets. Some of these Earth size planets may have 0.1% Carbon Dioxide, 2-5% inert gas, 85-90% Nitrogen, 10% or less water vapour. All other conditions being same this planet is Terraformable so we cannot abandon the planet. It is also possible that the planet may contain a very different atmospheric composition lacking oxygen. Lacking oxygen is an adverse condition for living organisms. Without oxygen abundance in the atmosphere ozone layer could not be formed. The absence of ozone layer will make the planet vulnerable to Suns UV radiation. Because of this, life cannot thrive on the planet. Below is the standard composition of Earth’s atmosphere.

Major constituents of dry air, by volume			
Gas		Volume	
Name	Formula	in ppmv(B)	in %
Nitrogen	N_2	7,80,840	78.084
Oxygen	O_2	2,09,460	20.946
Argon	Ar	9,340	0.934
Carbon Dioxide	CO_2	397	0.0397
Neon	Ne	18.18	0.00182
Helium	He	5.24	0.00052
Methane	CH_4	1.79	0.00018

Table-5.1, Composition of Earth's atmosphere

In such type of planets we have to live inside habitable domes to protect ourselves from Suns UV radiation. To protect the life inside the dome we have to neutralise UV B (315–280 nm), C (280–100 nm) and extremely short or vacuum UV (10–100 nm).

So depending on the density of air, quantity of elements present in them and the amount required to absorb UV rays we can built a UV absorption screen between the habitat and the outer atmosphere.

Hence we have built a structure which will protect humans from UV radiation. For living on outer planets, where air is not breathable and high UV radiation flux on the planet surface, humans have to live inside habitable domes, which will have pressurised breathable air.

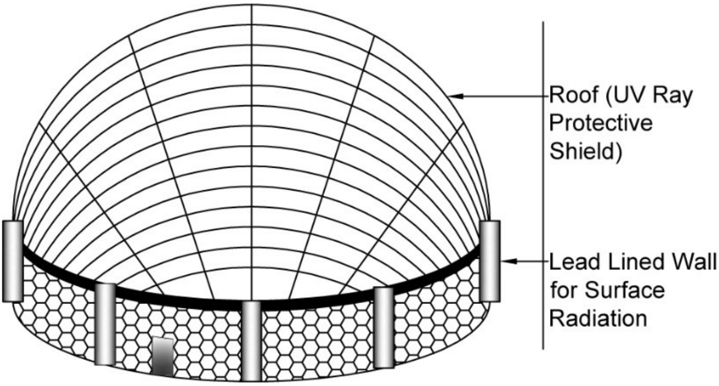

Roof (UV Ray Protective Shield)
Lead Lined Wall for Surface Radiation

Figure-5.1, Habitable Dome with Protective Shield against radiation

The structure above is a habitable dome. It will be huge enough to protect one settlement. It may be few kilometres radius. Its roof will be a double layer of glass or transparent fibre.

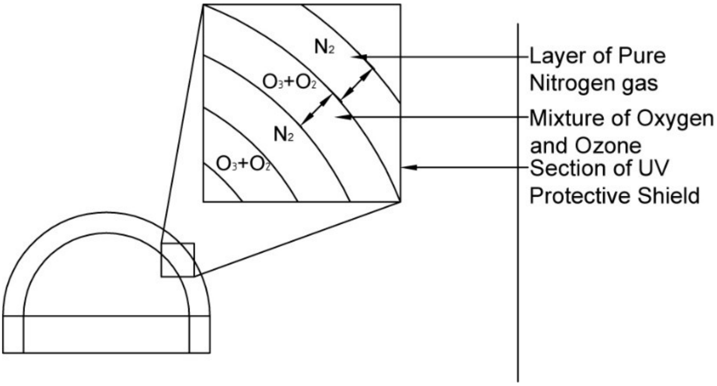

N2
O3+O2
N2
O3+O2
Layer of Pure Nitrogen gas
Mixture of Oxygen and Ozone
Section of UV Protective Shield

Figure-5.2, Cross Section of UV Protection Shield

Each arrangements will consist two layers of gas voids. One at the top will be filled with molecular nitrogen and the lower one will be filled with pure Oxygen. When the sunlight falls on the roof of the habitat the gasses inside the void will start to react. Nitrogen will absorbs the UV ray up to 100 nm and illustrate UV florescence, while UV-B and C will be absorbed by Oxygen, initiating Ozone cycle. After a certain period molecules in both the layers will be able to absorb desired UV radiation. As the reactions in both the layers are exothermic, we can control their speed and slow down the mechanism by controlling the temperature of the container. In this way, we will be able to create an artificial ozone layer to protect the inhabitants of the settlement.

To absorb the net UV incidence we have to use very dense layer of these gasses. This requirement can be overcomed, by arrangement of multiple layers of the same in much low-pressure condition.

Chapter-6
Paraterraforming

Paraterraforming is the method of turning a small part of the planet habitable by modifying its natural and environmental conditions. In this method humans have to live inside habitable domes, which are self-sustain ecosystems, proving the population with required food, sunlight, oxygen and water. These structures will protect humans from cosmic radiation, solar magnetic storms and toxic air of the planet.

In the process of Paraterraforming, we do not actually Terraform the whole planet, but we control the climate and environment of a small region. It can be said as small scale climate control. Humans require certain basic elements for their survival, so in Paraterraforming we have to consider those parameters as given below:

1. Breathable atmosphere
2. Protection from harmful UV rays
3. Protection cosmic and solar radiation
4. Food and water for inhabitants

Humans are evolved to live and grow under current environmental conditions on earth. Earth's gravity, magnetosphere, atmospheric composition and hydrosphere are unique in the universe. It will be difficult for humans to live under different conditions on other planet. But like every other organism we can survive extreme environmental conditions on the planet and slowly evolve for newly established planetary parameters.

We must choose a planet with surface gravity acceptable for human habitation to start Paraterraforming. The planet may be rocky with a thick or thin atmosphere of variable compositions, so the air will not be breathable for humans. There may not be liquid water available on the surface or found frozen in polar and subsurface regions.

To solve each of our deficits we have use different methods of small scale environmental control to build a habitable settlement.

Earth's atmosphere composed of Nitrogen (N_2) 78.084%, Oxygen (O_2) 20.946%, Argon (Ar) 0.934%, Carbon dioxide (CO_2) 0.0397%, Water vapour (H_2O) 0.001%–5% and other minor gasses.

Though humans breathe air, which is a mixture of number of non-reacting atmospheric gasses. They still can breathe even the atmospheric composition changes keeping the concentration of major gasses constant. The alternate atmospheric compositions which can be achieved for a Habitable Dome are:

Standard Habitation	
Nitrogen	60-70%
Argon and Helium	10-15%
Oxygen	22%

Table-6.1, Possible Atmospheric Composition of the habitation

UV B, C and short wavelength sun rays are harmful for living organisms. These harmful rays can be absorbed by the use of Spider Web Ozone method as described previously.

For radiation hazards we have to use deflector electromagnets. The walls of the habitation should be made of lead and Graded Z shielding method as described previously for radiation shielding. The surface of the settlement should be used as green house for producing food and air recycling of the habitation.

The greenhouses will be the place for plantation and recycling breathable air. The habitation should be settled below the green house to get maximum protection.

As the plants will require some amount of carbon dioxide for their life activity and converting solar energy into chemical energy, we will have to input some CO_2 inside the greenhouse. The atmospheres of habitable dome and the greenhouse will be different, both of them separate ecosystems, yet recycling matter from each other. Below is a standard atmospheric composition of Greenhouse by volume:

Green House	
Nitrogen	65-75%
Argon and Helium	10-15%
Oxygen	15-20%
Carbon dioxide	0.01-0.02%

Table-6.1, Possible Atmospheric Composition of the Greenhouse

The habitation and greenhouse are protected from cosmic and surface radiation by radiation shielding and electromagnets (Chapter-4). The transparent roof of the greenhouse is built to let sunlight pass through it. The greenhouse is protected from UV rays by spider web ozone (Chapter-5) method. Greenhouse produces the food for habitation and recycles the Carbon Dioxide. Below is a model of habitable dome on a distant planet.

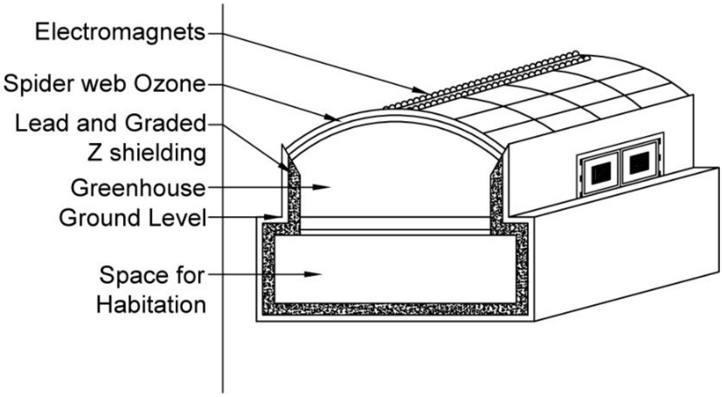


Figure-6.1, Paraterraforming, Model of a habitation

No machine is 100 percent efficient and there will always be some by-products which cannot be recycled. In this case we have input source of energy and matter from outside at regular interval. However the biosphere should be made for maximum efficiency to be self-regulatory and self-sustaining.

Chapter-7
Satellite Web Magnetosphere

There are planets, which produce very weak planetary magnetic field or planetary Magnetosphere is unable to deflect solar and cosmic radiation. If the planets magnetosphere is not strong enough to deflect Solar wind and cosmic radiation, the surface radiation will make human habitation impossible.

To initiate human settlements on these barren planets we have to create a radiation shielding method. However, some planet's atmosphere is so thick or dense that the sunlight does not reach the planetary surface directly. So due to the absence of direct sun light and dense atmosphere, the Giant magnetic Field model will not be applicable here. The secondary radiation on the surface of the planet will be hazardous for human habitation.

On those planets, we have to deflect solar radiation before entering the planet's atmosphere. For which we have to put magnetic deflectors on space around the planet as satellites. Below is a model of satellite electromagnet to deflect solar wind.

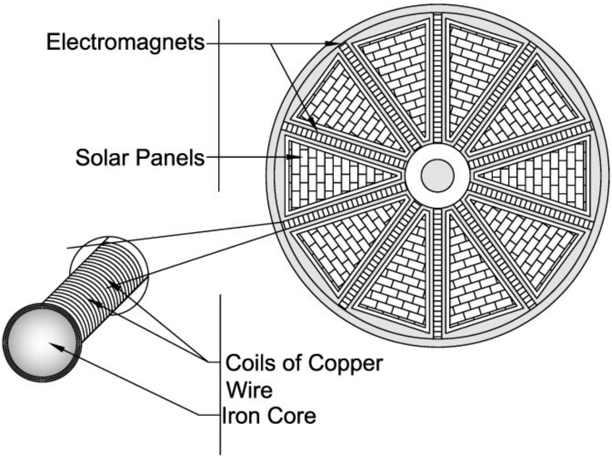


Figure-7.1, Typical Satellite Solar Wind Deflector

Above is a geostationary satellite with extended limbs of iron core electromagnets which will produce strong enough magnetic field. These electromagnets are arranged in radial manner and between the limbs solar panels will be placed to power the machine.

Geostationary satellites with their own strong magnetic field will be able to cover a large enough area for human settlement. We may have to use some secondary precautions, but habitation will be easier because of the satellites around the planet will deflect the major part of harmful radiations.

This setup will be placed in an orbit around the target planet. The satellite constitutes of number of electromagnets. When current flows through these electromagnets, they generate magnetic field. These satellite electromagnets will revolve around the planet in a geosynchronous path. Their position of can be controlled from Earth or the inhabiting planet.

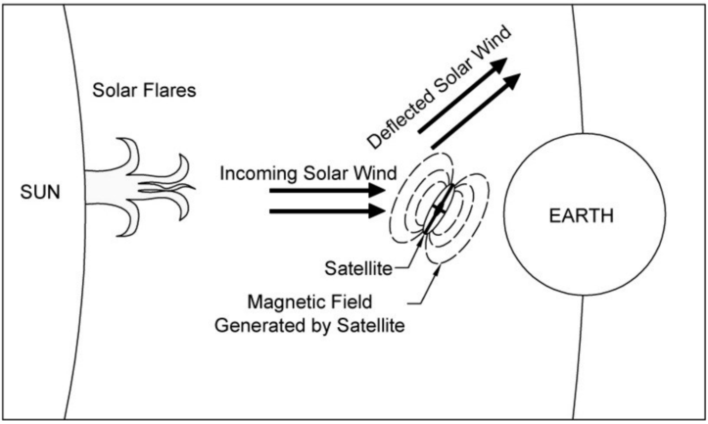


Figure-7.2, Mechanism of Solar and Cosmic Radiation Deflection

Moving around the planet one or number of these satellites will collectively deflect the solar wind and cosmic radiation entering the planet. Shadow zone of these satellites (area protected from solar wind) depends on the strength of the satellites magnetic field and distance of the planet from the sun of the solar system. So farther the planet more effectively the satellite magnetic field will be able to deflect incoming solar wind.

One or more of these will surround the planet to protect it from solar wind though other arrangements are required to stay safe from planet’s surface radiation.

Chapter-8

Gravity Chamber

There are four fundamental Interaction or forces which act for every matter in the universe. They are Nuclear Strong, Nuclear Weak, Electromagnetic Force and Gravitational Force.

Nuclear Strong force is responsible for binding of nuclei. This force is so strong that it binds and stabilizes the protons and neutrons within a nucleus. However, it is very short range. The second one is Nuclear Weak Force This force is responsible for nuclear beta decay and other similar decay processes involving fundamental particles. The Electromagnetic Force exists between all particles, which have an electric charge. Finally, the Gravitational Force is the force that holds us onto the Earth. However, force of gravity is always attractive it does not have an opposite pole. According to some graviton is the particle responsible for force of gravity.

Gravity is the property of mass. Every particle in the universe, which has mass, will attract other objects with mass. According to the law of gravitation, the force of gravity between two objects depends on the mass of two objects and distance between them. The force applied by an object with mass on another object is:

$F=G X m_1 X m_2/r^2$

Where: F is the force between the masses,

G is the gravitational constant

m_1 is the first mass,

m_2 is the second mass, and

r is the distance between the centres of the masses.

For the case of earth, force applied on any object is referred as:

$F=GMm/R^2$

Where:

M is mass of Earth

m is mass of the smaller object

R is the Radius of earth

Therefore, to stimulate gravity on a low gravity environment we have to manipulate mass, which is very difficult to achieve. In addition, to create gravity like on surface of Earth we require an object of mass of Earth. But gravity can be replicated using other forces of nature such as centrifugal force.

When a planet moves around a star, it experiences two types of forces Centrifugal force and Centripetal force. The centripetal force for planets is provided by the force of gravity. The centrifugal force is the result of inertia of the moving object.

Centrifugal force will provide necessary force to make humans feel earth like gravity. It acts outwards from the centre of rotation outwards.

Centrifugal force experienced by an object of mass M, moving in a circle of radius R with a velocity V would be:

$F=MV^2/R$

To experience gravitational acceleration like on earth we have to calculate the velocity of the moving object:

$F=Ma$ (force applied on an object is the product of mass of the object and acceleration of the object)

For an object falling on Earth:

$F=Mg$

So to achieve the necessary acceleration due to gravity g:

$\Rightarrow g=F/M$

$\Rightarrow g= MV^2/RM$

$\Rightarrow g=V^2/R$

$\Rightarrow V=\sqrt{}gR$

$\Rightarrow V=\sqrt{}9.8 \text{ X } 1000 \text{ X } m2/s2$ (let Radius of the Space ship 1KM)

$\Rightarrow V=\sqrt{}980m2/s2$

$\Rightarrow V=31.3$ m/s

So if the space ship rotates at a speed of 31.3 m/s in a radius of 1km, it will create acceleration due to gravity similar to surface of Earth.

Below is a model of Gravity chamber, which can be used as a space ship or a setup on a smaller planetary object.

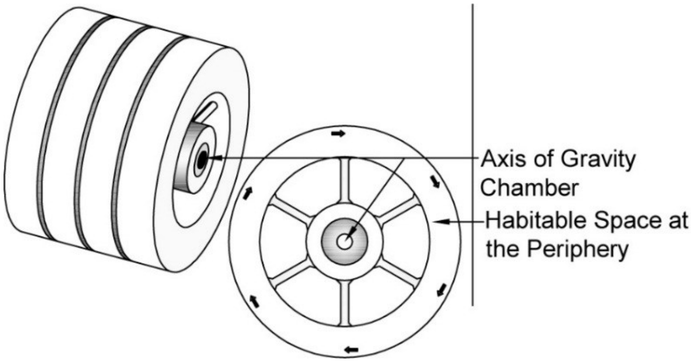


Figure-8.1, Structure of Gravity Chamber

Donut shaped hollow connected chambers rotating around an axle. As the gravity chamber rotates around the axle centrifugal force acts on each point on the floor of the chamber. This force is stronger as we move away from the centre of rotation. The value of gravity depends on the radius of the rotation and speed. So we can rotate the chambers around a stable axis, which will be the place for engine room and other instruments. Gravity chambers will be used for everyday living and research purposes, where we will experience normal gravity like earth. A gravity chamber can be of variable size depending on our requirement.

Gravity chamber can be made inside a spaceship or living on a low gravity planetary bodies. It will provide space for day to day human activity and laboratory.

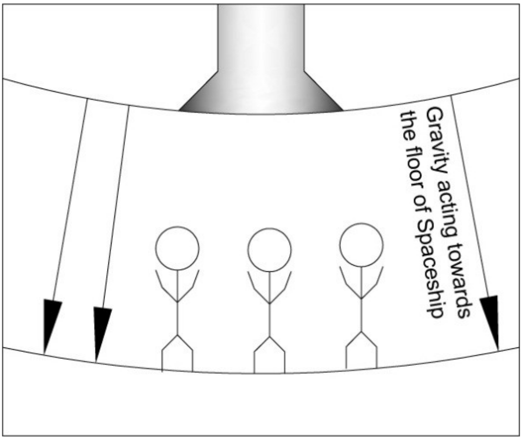


Figure-8.2, Effect of gravity on humans inside the Gravity Chamber

Chapter-9
Magnetic Floor Gravity

It is always difficult to work in low gravity condition. It may be a space ship or on a satellite or a planet, it is difficult to walk on the surface, and perform day to day activity in low gravity environment. But, for scientific expeditions or temporary settlement, we will require to work for hours to make every system run properly. On the surface of earth it is experienced due to Earths mass, because of which are able to walk on the surface of earth.

Earth's surface gravity like condition can be reproduced in low gravity environment with the help of magnetism. Though this method will not compensate the low gravity, it will help space dwellers to work smoothly.

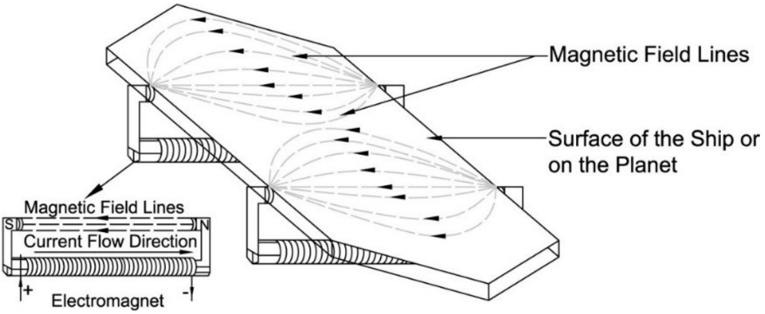


Figure-9.1, Construction of Magnetic Floor

For space ships or surface on other planets, where gravity is low we can use this method to stimulate artificial gravity for making human activity easier. For this we will have to make the floor magnetised. As the floor is magnetised it will attract other magnetic materials. Humans will have to wear magnetic space suits. These suits will be easier to wear as they are like normal scuba diving suits only with a coating of Ferro-Magnetic material on the outside. Humans also have to wear shoes of the same material coating.

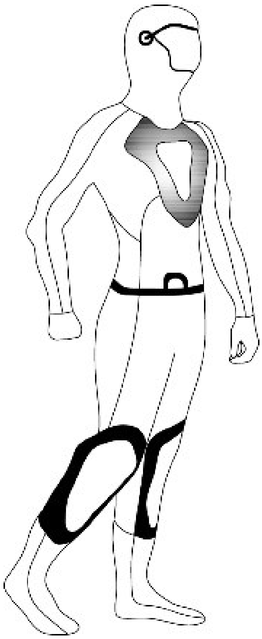


Figure-9.2, Magnetic Suits

We have to keep the magnetic field intensity of the floor minimum, so that it will only attract objects close to it, considering that the magnetic field produced will not affect laboratory instruments. So for a man walking on the floor with his suit on will be attracted towards the floor. His feet will be attached to the floor and the effect will decrease towards his head. As a result humans will be able to walk easily on the surface and carry out research activity in earth like gravity condition.

The same can be achieved with better effectiveness if we use a viscous liquid inside the habitation instead the air. For achieving artificial gravity we shall use a liquid, whose viscosity increases as we go up. Density of the liquid will vary from the floor to top of the habitation slowly getting denser. As the viscosity of the liquid increases as we move up, our body will experience a continuous downward force. This hydrostatic pressure will keep us on ground. So humans will experience an earth like gravity environment.

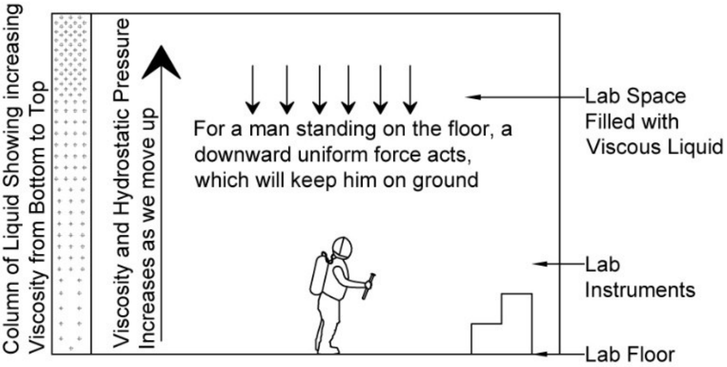

Column of Liquid Showing increasing Viscosity from Bottom to Top
Viscosity and Hydrostatic Pressure Increases as we move up
For a man standing on the floor, a downward uniform force acts, which will keep him on ground
Lab Space Filled with Viscous Liquid
Lab Instruments
Lab Floor

Figure-9.3, Viscous liquid filled chamber for gravity effect

Chapter-10

Underground Pressurized Chambers

In future with new technological advancements, we will be able to travel to distant solar systems. There is no guaranty that we will find habitable planets for humans. Therefore, we have to terraform them according to our requirement.

Planets inside and close to the habitable zone are not always safe for habitation. If the planet is near an asteroid belt, the risk of impact will be higher, this may cause frequent damage to the settlement. In some cases where the planets or satellites are close to gas giants of the solar system the radiation level on the surface will be lethal for human activity. So Human Habitation will not be favourable under such conditions.

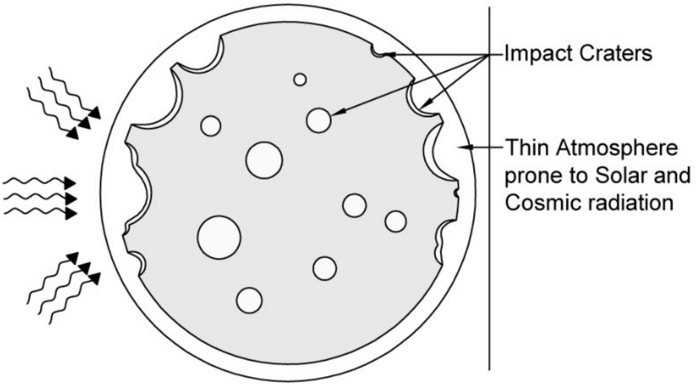


Figure-10.1, Planet near Asteroid Belt

So in above said conditions we cannot establish settlement on the surface of the planet. To live on these planets humans have to live inside these planets or we have to build underground settlements.

Impact of asteroids generates shock waves. These shock waves travel from the place of impact outwards. Impact not only generates shock waves it also produce a huge amount of energy. This heat energy causes rock melting and vaporization. A large amount of dust which is thrown to atmosphere due to impact remains in the atmosphere for a long time and makes the planet un-inhabitable.

The effect of radiation is adverse on living organisms. Cosmic and solar radiation causes damage to living cell. Gas giants of solar system have very strong magnetic field. The high energy electrons, protons and alpha particles coming from sun and space get trapped inside the planetary magnetosphere. In gas giants, the magnetosphere of the planet is very large and composed of multiple spheres of charged particles floating around the planet with different speeds. These charged particles collide with the neighbouring planets and satellites during their journey in space around or close to the planet. This intense surface radiation on the surrounding planets makes them inhospitable.

Such effects of radiation and impact can be avoided only if we live below the surface. As we go deeper in to the planet, we shall experience lesser effect of cosmic and solar radiation from the surface. Alpha particles and protons can be neutralised by thick rock strata above the settlement.

The shock waves produced because of impact, their force and effect decreases proportionately, as we move away from the point of impact. If we chose to build the settlement at greater depth, the effect of asteroid impact will be lesser. To neutralise these risks fully, we have to take some secondary measures.

For the radiation shielding we do not have to do much because the depth will take care of the radiation. The residual radiation can be absorbed by Lead (Pb) sheets to protect the population. Or Graded Z shielding is another method for that. Graded Z shielding is a method in which we use layers of materials with variable Z (Atomic Number) value, so that their effective density obstructs the radiation.

After the impact, the shock waves will propagate from the point of impact, outward and downward. As the wave travels through the planets interior its intensity and effect decreases depending on the force of impact. So the energy of shock waves reaching other side of the planet will be Insignificant. The shock waves will attack on the habitation mostly from top and sideways.

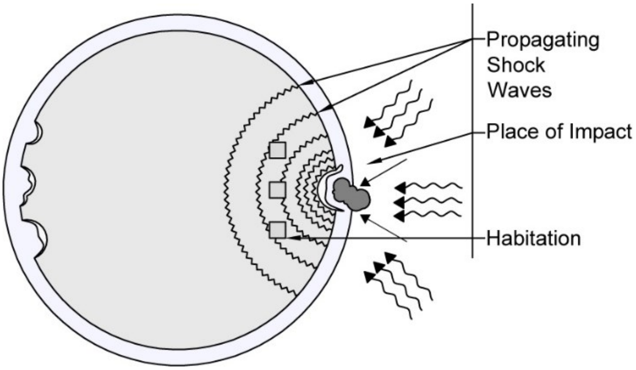


Figure-10.2, Propagation of Shock Waves through Underground Pressurized Chambers

Below is a model of underground pressurized chamber. The habitation will be a tunnel shaped residence. From outside, the tunnel will be covered with radiation shielding material. This arrangement will neutralise the radiation before penetrating the habitation. Below the outer radiation shield, there will be a layer of viscous liquid to absorb the energy of shock waves. Inside the square shaped tunnel there will be two independent round tunnels. Humans will live inside the central circular tunnel. The outer and inner tunnels are connected by springs, pushing the central tunnel to its correct position. Inside the central tunnel the whole habitation will be balanced by two hydraulic jack systems which will absorb the residual shock waves during impact.

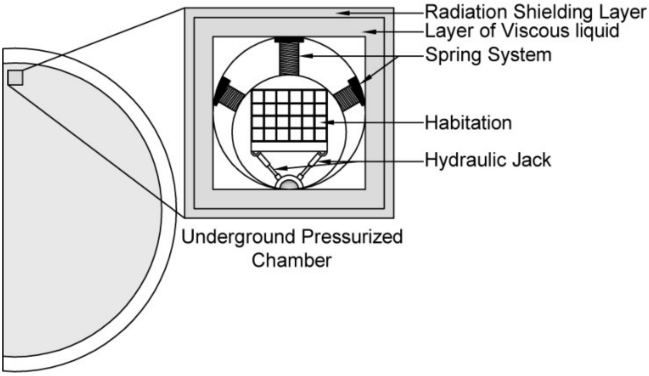


Fig-10.3, Structure of Underground Pressurized Chambers

Underground pressurized chamber is a proposed model for living on these deserted planets. As shown above an underground pressurized chamber will be built below the ground at such depth not to be affected by radiation or asteroid impact.

The outer radiation shielding will protect the habitation from solar and cosmic radiation. The impact waves travelling through the rock strata will travel through the tunnel. The primary shock will be obstructed by the liquid and the rest will be absorbed by the spring and hydraulic jack system. This whole system placed below the ground will help humans to travel further setting a temporary settlement and a base for future travel to distant solar systems.

Chapter-11
Subsurface Hive

We may find planets with Ice sheets covering the surface, dense atmosphere and enough gravity to be considered for settlement. But as the atmospheric temperature is much below the freezing point it will be difficult to establish settlement on surface of those planets.

As the planet is distant to its sun and covered by ice the planetary magnetism may be dead due to cooling of the core. So the surface of the planet will also be inhospitable because of cosmic radiation.

For such planets humans have to live inside sub surface hive. The planets have no magnetosphere which means its liquid core has been solidified. We still can live deep inside the planet close to the core of the planet as at higher depth, we may get the necessary heat from residual geothermal gradient of the planet.

Similarly if the planet is close to the Sun of the solar system the surface temperature will be high enough to make it uninhabitable. But if the core of planet is no more in molten state, we can live inside subsurface hives. There we will not be affected by intense solar and cosmic radiation.

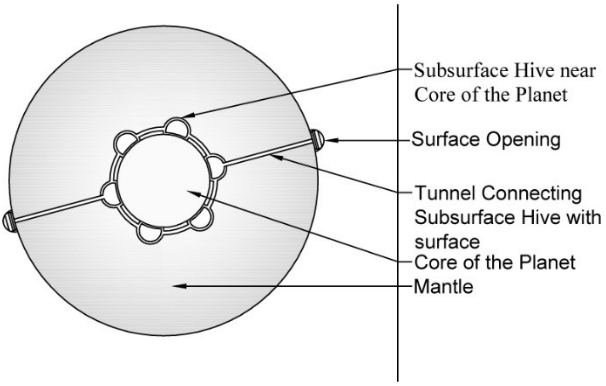

Subsurface Hive near Core of the Planet
Surface Opening
Tunnel Connecting Subsurface Hive with surface
Core of the Planet
Mantle

Figure-11.1, Subsurface Hive close to the Core of the Planet

Above shown is a model Subsurface Hive. The habitation should be built at deeper parts of the planet. Close to the core of the planet, habitation can get the necessary heat as energy for life activity. At such depth settlement will stay intact from impact and radiation hazards.

Chapter-12
Dissociation Vessel

As we move away from the central star of a solar system, we shall find Gas Giants (Planets like Jupiter and Saturn) and Ice Worlds (frozen planets). The surfaces of some these Ice Worlds are covered with kilometres of thick ice sheets underlain by 100kms deep liquid ocean water. Some suggest that these huge oceans may nurture life. In our solar systems Europa, Ganymede and Callisto, Satellites of Jupiter show the same characteristics. In Some solar systems planets inside habitable zone contain huge reservoirs of water. In such cases the whole planet is covered with kilometres of deep saline ocean water. These planets are called water worlds.

As life may have evolved on these Ice Worlds, we should not interfere in the planet's ecosystem. Due to extreme low temperature humans have to live below the ice sheets inside oceans of water to stay protected from cosmic radiation. As the water at such depth is under immense hydrostatic pressure we have to live inside pressurized space ships.

Water is the major source of life activity on earth. It is also known as universal solvent and plays an important role in cellular activity. It dissolves and carries all the nutrients, salts and chemicals required for cellular activity.

Water is the source of Oxygen on the planet Earth. Photochemical dissociation of water produces oxygen and hydrogen gas. At the upper atmosphere by the action of UV rays water molecule breaks into H_2 and O_2.

$2H2O+ hv \leftrightarrow 2H2+ O2$

(hv is the energy absorbed by a water molecule to dissociate, where h= Planck's Constant and v= frequency of the photon)

There is another way to dissociate water, the simplest one, Electrolysis. Electrolysis of water is the decomposition of water (H2O) into oxygen (O2) and hydrogen gas (H2) due to an electric current being passed through the water.

Below shown, is a simple setup for electrolysis of water, known as Hofmann voltmeter. It consists of three joined upright cylinders. The inner cylinder is open at the top to allow the addition of water and the electrolyte. A platinum electrodes are placed at the bottom of each of the two side cylinders, connected to the positive and negative terminals of a source of electricity. When current is run through the Hofmann voltmeter, oxygen gas forms at the anode and hydrogen at the cathode. Each gas displaces water and collects at the top of the two outer tubes, where it can be drawn off with a stopcock.

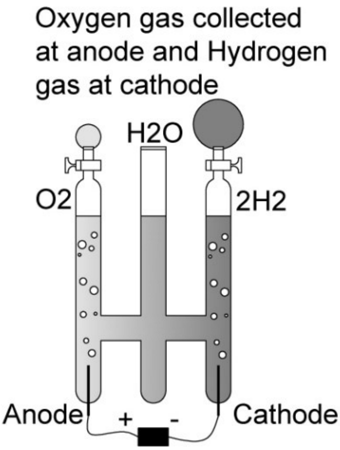


Figure-12.1, Electrolysis of water with Hofmann voltmeter

At the positively charged anode, an oxidation takes place, generating oxygen gas and giving electrons to the anode to complete the circuit:

Oxidation at anode: $2\ H_2O\ (l) \rightarrow O_2(g) + 4\ H^+(aq) + 4e^-$

In pure water at the negatively charged cathode, a reduction reaction takes place, with electrons (e^-) from the cathode being incorporated by hydrogen cations to form hydrogen gas:

Reduction at cathode: $2\ H^+(aq) + 2e^- \rightarrow H_2(g)$

The same half reactions can also be balanced with base as listed below.

Cathode (reduction): $2\ H_2O(l) + 2e^- \rightarrow H_2(g) + 2\ OH^-(aq)$

Anode (oxidation): $4\ OH^-(aq) \rightarrow O_2(g) + 2\ H_2O(l) + 4\ e^-$

Combining both half reaction pair we get, the overall decomposition of water into oxygen and hydrogen:

Overall reaction: $2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$

Generally in electrolysis an electrical power source is connected to both electrodes, or two plates (typically made from some inert metal such as platinum, stainless steel or iridium) which are placed in the water. Hydrogen will appear at the cathode and oxygen will appear at the anode. All the circumstances being the same, the amount of hydrogen generated is twice the amount of oxygen, and both are proportional to the total electrical charge conducted by the solution.

Electrolysis of pure water requires excess energy in the form of over potential to overcome the activation barrier for ionisation. Without the excess energy, the electrolysis of pure water occurs very slowly. Pure water has an electrical conductivity about one millionth that of seawater. Most important element in this process is choosing a suitable electrolyte, since an anion from the electrolyte is in competition with the hydroxide ions to give up an electron. An electrolyte anion with less standard electrode potential than hydroxide will be oxidized instead of the hydroxide and no oxygen gas will be produced. A Cation with a greater standard electrode potential than a hydrogen ion will be reduced and no hydrogen gas will be produced. Using NaCl (table salt) in an electrolyte solution results in chlorine gas rather than oxygen due to a competing half-reaction. With the correct electrodes and correct electrolyte, such as baking soda NaHCO3, hydrogen and oxygen gases will stream from the oppositely charged electrodes. Oxygen will collect at the positively charged electrode (anode) and hydrogen will collect at the negatively charged electrode (cathode).

There are many water worlds in our and outer solar system. Surface of these planets i.e. upper crust consists of very thick Ice sheets. Below the thick Ice sheets there are huge oceans of water. The atmospheres of these planets are oxygen rich. But due to cosmic radiation, impact risks and extreme surface temperature we cannot live on such planets. While we can live inside the deep oceans, below the ice sheets and get the required elements for life activity. These huge oceans are the potential place for existence of alien life forms.

Even if we do not find life in those planets, still we can use the available natural resource, water and the dissolved salts. By living inside an ocean, we can get the necessary Oxygen, food and water for our habitation. With number of self-sustaining ecosystems, we can get the required food and oxygen for our life activity.

Below is a model Dissociation Vessel, which can be used for both settlement and production of food and energy for humans.

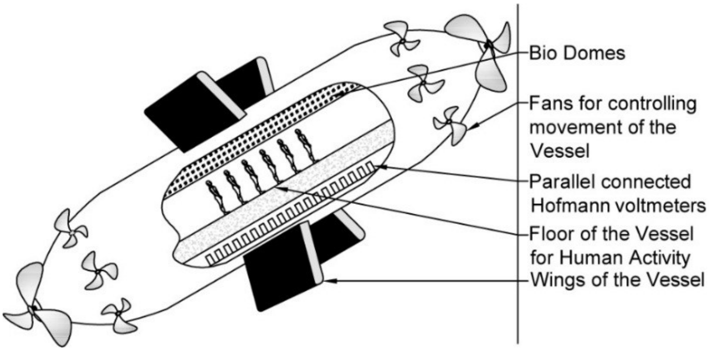

Bio Domes
Fans for controlling movement of the Vessel
Parallel connected Hofmann voltmeters
Floor of the Vessel for Human Activity
Wings of the Vessel

Figure-12.2, Model of a Dissociation Vessel

The lowest chambers of the ship will be the electrolysis platform. In which number of Hofmann voltmeters are connected in parallel connection with the source of electricity. The water is pumped into the machine. As a result of electrolysis Oxygen and Hydrogen are generated from the electrolysis. The oxygen will be directed to living chambers while the Hydrogen will be directed to the engine room and used as an efficient fuel. The main platform of the ship can be used for human activity, control room and research purpose. The upper compartments will be used for building Biodomes (self-sustaining ecosystem). Biodomes are self-sustaining ecosystems inside which energy and matter recycles to produce food and required materials for a small population of humans. With minor modifications and input of matter, we can use these Biodomes to produce enough food for humans.

While living inside a water world, if we do not have any source of energy, we have use H2O dissociation as a way to get the necessary oxygen and hydrogen as fuel for our activity. In this method without Terraforming the planet, we will be able live inside giant water worlds of outer solar systems. In such planets, Dissociation Vessel can be used as habitation for a sizable population of humans.

Chapter-13
Extraterrestrial Influx

There are many planets, which contain none of the required elements for human habitation. It is possible for some reason we may have to live on planets or satellites, which have no atmosphere, geomagnetic field or subsurface storage of water or Ice.

In such cases, we have to depend on closest planets, satellites and asteroids. Asteroids and meteorites contain all the necessary elements for human life. Asteroid mining is the extraction of required materials from asteroids. From asteroid we can get required ice, metals and some planets may also offer us required fuel inform of hydrogen and radioactive elements. Many satellites contain reservoir of ice in their polar region. We can use that Ice for our life activity. Asteroids and meteorites contain many necessary elements like Iron, Nickel and other Metals. They can be useful for us on an alien planet.

For asteroid mining we can use robotic miners (spaceships), which are programmed to travel from our planet to approaching or near about asteroids and planetary bodies. These can work in low gravity condition. These spaceships will have tentacle shaped attachments with which they will attach themselves to the target body. The asteroid and the spaceship will be connected by an airlock hatch. Through this path humans or machines can dig the host and carry away the required material to base. Below is a model spaceship which can be used for asteroid mining.

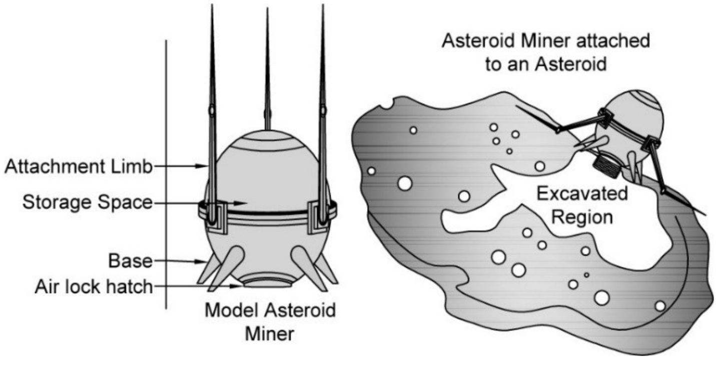


Figure-13.1, Robotic Miners used for Asteroid Mining

From asteroid mining, we can get all the necessary elements we require for building a temporary settlement on an alien planet.

Chapter-14

Hollow Satellite Settlement

Terraforming a planet requires a vast source of energy, natural resources and quite a long time span. There are possibilities, that we may have to leave our home planet in a hurry for the incoming catastrophe and we do not get enough time to Terraform a planet.

In those cases, we can settle on a satellite like Moon, Phobos or Deimos close to our planet or a habitable planet while we are searching for other suitable places. In space we have to face a number of adverse conditions like cosmic and solar radiation, low gravity and lack of water, food and breathable air.

Living below ground surface we can avoid the effect of radiation. Because packed soil provides appreciable radiation shielding. Below there is a chart of materials used for radiation shielding. A thick layer of soil is a cheap shield against radiation while sand and clay are little more effective than soil.

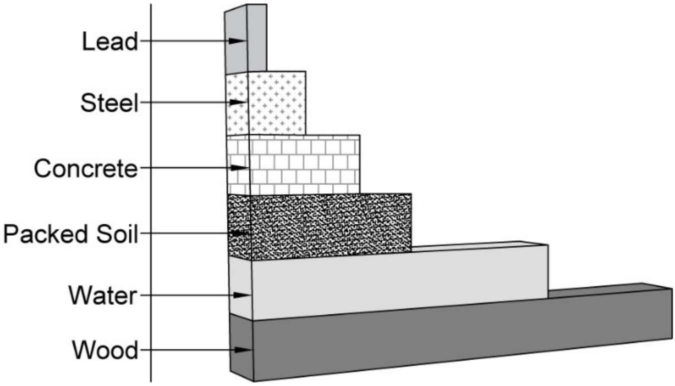


Figure-14.1, Radiation Shielding of different materials

May satellites of solar system contain water in form of ice in there polar region and deep impact craters. We can use the water from those places for our habitation, but for that we have to transport it. Instead, we can build our settlement on the satellites.

Living inside a small planetary body like a satellite can be profitable in many ways, as:

1. Impact risk will be lower, as the planet with smaller mass will attract less number of the incoming cosmic debris and meteorites.

2. Because of low gravity space journey will be easier i.e. leaving the platform will require less energy.
3. We can capture meteors and asteroid to extract our necessary materials like metal, ice and Fuel.
4. Living inside a satellite will protect us not only form impact, but from cosmic radiation.

Small satellites have lower mass, resulting low surface gravity and a very thin or residual atmosphere. The molten core of these satellites and planets solidify, as the interior heat could not be trapped inside for long time period. But they still may contain polar and subsurface reservoir of ice, radioactive minerals and required metals for human habitation. We can live on those planets and exploit its resources.

We may find Terraformable planets, which are in hospitable for now and humans cannot settle on them in near future. We can build Hollow Satellite Settlements near these planets or inside their satellites to consume natural resources and Terraform them.

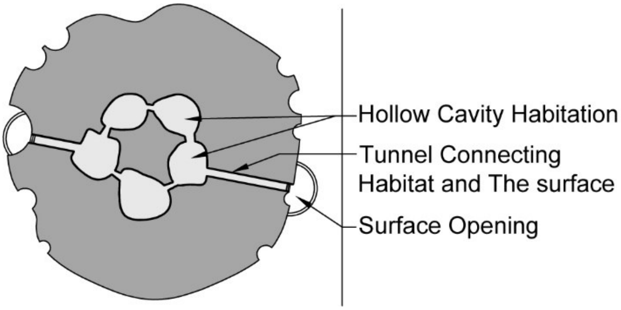


Figure-14.2, Hollow cavity habitation inside the satellite

Above is a model of hollow satellite settlement, near the core of the satellite, where the impact effect will be less. Hollow cavities near the centre of the planet will provide necessary space for human activity. Humans can live inside these contained habitations. Artificial gravity can be stimulated to make human activity easier.

Hollow Satellite Settlements will be helpful for humans, when we could not afford to spend a very long time span or natural resources. As given above a satellite cavity will provide space for human habitation.

Chapter-15
Artificial Robot Planet

The concept of artificial planet is not new to us. As many science fiction stories tell about huge engineered spaceships with their own power supply and artificial gravity. It is difficult to build such spaceships with current technology, but in future with advancement of technology we will be able to build such mega structures.

We are using satellites for our communication and information collection for a long time. If those satellites could be made large enough to sustain its own self replenishing ecosystem and artificial gravity it can be compared to an artificial planet. Currently we have ISS (International Space Station) placed on an orbit around our planet, which is a smaller version of Robot Planet. If ISS can be made bigger, it will be able to support thousands of peoples. But we need the artificial planet to be more complex and powerful so that it can change its orbit on its own and travel to distant galaxies.

There are two ways to build an artificial planet. One is known as “cube of cubicles’’, which is explained as a large structure made of small building blocks. For this purpose we can send a number of Space Ships into orbit around the planet, which are parts of the Mega Structure. Each Space Ship (building block) is built in such a way to fit with each other. We can integrate those in orbit, this will be easier for us, rather than to unite the entire arrangement on earth. Collectively they will form a planetary skeleton for us. Then on the skeleton we can expand the planet according our needs.

Or we can start with a small Planetesimal, satellite or asteroid using them as a skeleton and build habitation around them. It will be much easier to do so as we have a solid ground with low gravity.

Below is a depicted model of Robot Planet. It is built by joining parts of the planet in space. On such planets we can achieve artificial gravity by centrifugal force as described before.

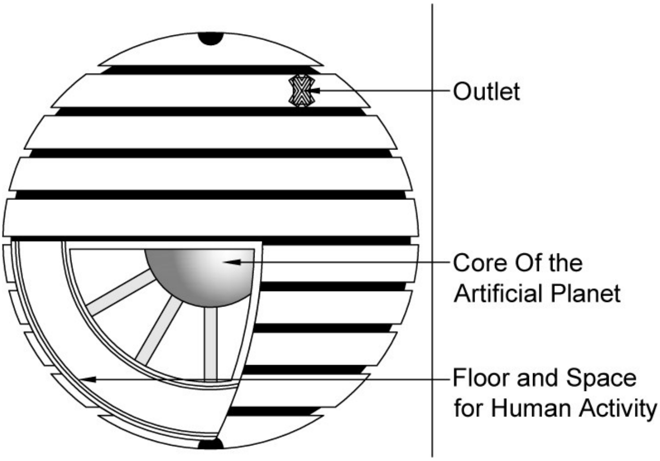

Outlet
Core Of the Artificial Planet
Floor and Space for Human Activity

Figure-15.1, Artificial Robot Planet

Artificial planets can be constructed around a planetesimal or asteroid. In this case we can save some of our natural resources, as the asteroid will act as the core of the artificial planet and base for building the Macro Structure. Such planets will be stronger than previous ones. But it will be difficult to stimulate gravity in such planets. Below is a depiction of artificial planet built with asteroid skeleton.

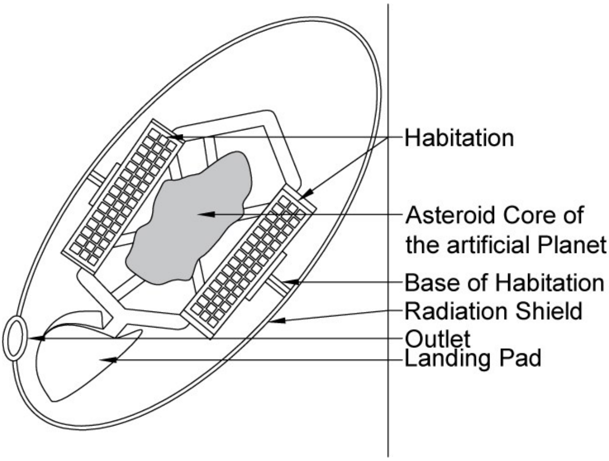


Figure-15.2, Artificial Planet Asteroid Core

The planet will be huge enough to accommodate large population of humans and orbit around a star or a planet. Stimulation of artificial gravity by any means is necessary to create earth like environment. As a whole, the planet should be a Bio-Dome or Closed ecological systems, so that the requirements of food and breathable air could be fulfilled from inside the planet. On the other hand, we can rely on outside sources for energy, Breathable air and Metals.

Chapter-16
Gravity Capture

Every organic life form requires some basic ingredients to sustain and live on a planet. Organisms grow and evolve with time by consuming the natural resources of the planet. They reproduce and populate the planet. With their growth and increasing population they consume more amounts of natural resources.

On earth we are using all the natural resources for our growth and development. We depend on both renewable and non-renewable source of energy. Non-Renewable sources of energy are not recycled by nature, so once consumed they cannot be replenished in distant future. When we burn fossil fuels we get Carbon Dioxide/Monoxide, Nitrogen Oxides, Sulphur Dioxide, Volatile Compounds and Energy. While a certain amount of reserve is available in nature. So with current rate of consumption all our fossil fuels will barely last till 2080.

But Renewable source of energy are hope for mankind. Solar Energy, Hydro power, Tidal energy and Geothermal heat can be used, yet recycled by nature. Nuclear Energy is more efficient, though it is non-renewable source of energy. But radioactive minerals can be extracted from other planets and asteroids for generating Nuclear Energy. For living, humans also need breathable air, water and food. Water and air may not totally be consumed one day but they are being polluted due to human interference.

Because of these reasons humans have to search for sources of energy and required elements from outside earth. Sources of the required minerals and elements can be found easily in asteroids. Therefore, to extract the necessary ingredients we have to bring the asteroid close to earth and put it around earth in an orbit. We can use following methods for capturing an asteroid.

Solar sail is one of cheapest and most efficient space propulsion technology. It takes a long time to achieve desired speed. So it is not used so frequently. But this can help us with asteroid deflection. We have to send many solar sails to reach the asteroid belt. They will attach themselves to the asteroid. Then the solar sails will align themselves using the radiation pressure of sun and the asteroids will start deviating from their current course and follow the desired course, as the Solar Sail slowly pushes it.

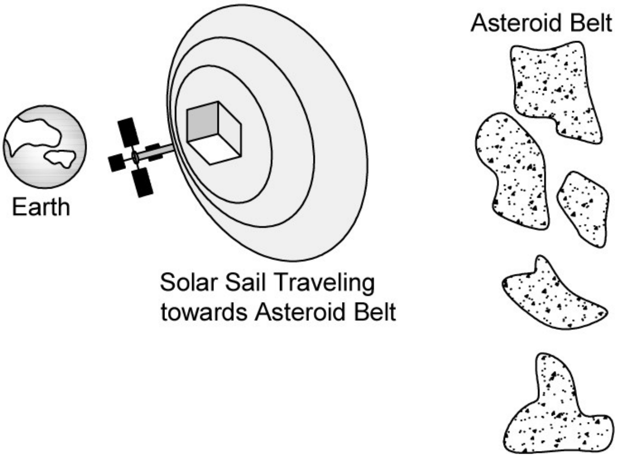


Figure-16.1, Solar Sail approaching the Asteroid Belt

For capturing an asteroid, we have to deflect the path of an asteroid and bring it close to earth's gravitational field. There are many methods of deflecting the path of asteroids. We can use them to put an asteroid in orbit around earth or Moon. Then we can extract the necessary material from the asteroid and divert it in desired direction.

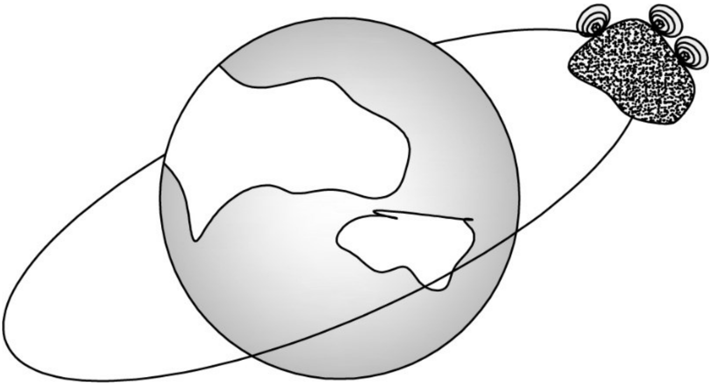


Figure-16.2, Asteroid Captured by Earth's Gravity

Secondly, we can deflect any distant asteroid with gravity capture. It is a method which involves number of high energy laser beams, which are focused close to the path of the asteroid. The cumulative effect of these beams creates a gravity channel, and the asteroid is dragged towards the focus point. In this manner the asteroids path can be diverted.

This method can also be used to avoid asteroid impact on Earth. If an asteroid is following a parabolic path around Sun and its path intersects with earth's orbit, there is a possibility of collision. To avoid this we have to identify the near earth objects before getting close to our planet. Then with the help of any one of the methods, the asteroid can be deviated.

Part-3: Terraforming

Chapter-17

Triggering Magnetic field with Asteroid Impact

Magnetosphere is one of the most important characteristic of a planet to sustain organic life. Earth is protected from the solar and cosmic radiation by the presence of its Magnetosphere generated by the outer core of the planet. Inner core of Earth is in solid state and the outer core is in liquid state composed primarily of Iron and Nickel. Due to difference in temperature and composition between liquid inner core and the Mantle of the planet. The movement of high temperature Fe-Ni melt creates current which then gives rise to associated magnetic field. This magnetic field is the protective shield of earth against Solar and Cosmic radiation.

But the question is how the Outer Core of the planet maintains liquid state while the Mantle in semi liquid state and the Inner Core in solid state?

Mantle remains in semi liquid state because of the lower temperature compared to outer core while the inner core maintains solid state because of immense pressure exerted on it by the upper layers of Earth. Iron is the main constituent of outer and inner core. With increase in pressure melting point of solids increase, therefore the inner core remains in solid state being at higher temperature than outer core. The heat which keeps the outer core in molten state comes from variable sources.

❑The main source of earth's internal heat is the adiabatic pressure. This pressure is the result of the immense lithostatic pressure applied on every square cm of earth.

❑The second is the radioactive decay. Presence of heavy elements like Uranium, Thorium etc. generate heat by radioactive decay releasing energy in form of heat.

❑Another one is the trapped heat inside the earth during the formation of the planet.

Due to convection, this heat travels from one region to other with molten rock and metals. So eventually the trapped heat reduces. Very small amount of the earth's internal heat is lost through its surface every day. With time the radioactivity will slow down and stop. And after certain point the adiabatic heat generation will stop too. This is the time when earth's outer core will stop to work as it will freeze. Once it freezes there will be no convection current in the outer core, resulting the disappearance of magnetosphere.

During our journey through the distant solar systems we may find planets, in which the core generated magnetism is dead. The liquid core of the planet may have solidified, due to which the planet has become inhospitable in absence of planetary magnetosphere. By controlled impact of asteroids we can restart the convection process i.e. Geodynamo inside the core of the planet.

To remelt the core in the process of regenerating the magnetosphere around the planet we have to examine the planets internal geological structure and composition and look for following parameters.

❑Planet should be a terrestrial planet i.e. it's should mainly composed of Silicate Minerals and Iron.

❑Planet should have a magnetic field of its own in past geological history.

❑Planet should have a well differentiated interior i.e. the interior of the planet should be divided to Crust, Mantle and Core (Outer and Inner).

❑The outer core along with the Mantle and Asthenosphere (layer of magma below the Crust) should be in solid state to help faster propagation of shock waves.

❑Planet should be >60% size by mass and volume of earth, with a very thin atmosphere.

Asteroids and meteors regularly strike the surface of earth since the origin of the solar system. When a solid object strikes a planet's surface it generates huge amount of energy. This energy is spread to the environment in form of heat, noise and shock waves. An impact is always associated with shock waves. There are 3 types of shock waves which propagate from the place of impact namely:

1. P-Wave (Primary Wave-Longitudinal Waves)

P-Wave also known as Primary waves are longitudinal waves i.e. the wave transmits via oscillation of particles in direction of wave propagation. This is known as body wave as it travels towards the interior of the planet from the point of impact.

2. S-Wave (Secondary Wave-Transverse Waves)

S-Wave also known as Secondary waves are Transverse waves i.e. the wave transmits via oscillation of particles in direction perpendicular to wave propagation. This is also a body wave.

3. Surface Wave

Surface Waves are both Longitudinal and Transverse Waves. They travel only on the surface of earth outward from the place of impact.

P waves are also known as pressure waves because they travel with alternate compression and rarefaction in the medium. They travel faster than S-waves and they can travel through solid, liquid and gaseous medium. So the possibility of P-Waves travelling to deeper parts of the planets interior is more. In an Isotropic medium propagation of P-wave is always longitudinal, yet they deviate from their path when changing the medium i.e. refract due to change in density and composition of the medium.

Velocity of transverse waves (v) on a string is calculated as:

$v=\sqrt{T/\mu}$

Where T= Tension and μ= mass per unit length

For the Velocity of transverse waves in solid medium we will have to consider Bulk modulus and Shear Modulus against Tension and Density of the medium against mass per unit length.

So the velocity of P-wave in a given solid medium will be calculated as:

$V_p=\sqrt{\{(k+4\mu/3)/\rho\}}$

Where;

V_p =Velocity of P-wave

k=Bulk modulus,

μ=Shear Modulus

ρ=density of the medium

In above case we calculate the velocity of p wave depending mainly on Bulk modulus.

But if the medium is under isotropic pressure condition, uniform pressure applied on it from all sides, the medium will behave as given below:

Density of a medium, $\rho \propto P$, applied pressure

Volume of a medium, $v \propto 1/P$

Temperature of a medium, $T \propto P$

So $P \propto \rho T/v$

So when P-Waves travel through any medium they generate alternate compression and rarefaction or alternate regions of high pressure and low pressure inside the medium. Density of the medium is proportional to applied pressure on the medium, which is again related to the state of the medium, so there comes a time when this rarefaction created molten mass of the medium.

So $P \propto \rho T/v$

$\Rightarrow P = A\rho T/v$

A can be said Aryabhatta Modulus for the medium. “A” Aryabhatta Modulus defines the state of the medium. A represents the energy state of a substance which increases with increasing pressure.

So $P \propto A$

If the planetary geological conditions are as discussed above, from the place of impact P-waves will travel towards the interior of the planet, with minimum loss of energy. When they reach at the deeper parts of the planet i.e. lower mantle, outer core and inner core which are at high pressure condition, its velocity will gradually increase with increased density and uniform pressure. But at such high pressure and temperature condition slight change in pressure i.e. a wave of rarefaction will create rock melt. But with the next arrival of compression this melt will not solidify as this melt will escape away from the high pressure zone via inter granular spaces. With multiple impacts large volume of molten mass will be produced near lower mantle.

For starting the Geodynamo of a planet we have to use Asteroids as tools of our experiment. The residual parts of early solar system evolution, known as asteroid are found in solar system, preliminarily at Asteroid belt between Mars and Jupiter. Another one clusters asteroids found in Kuiper belt outside Neptune. For this purpose we shall use asteroids from main Asteroid belt, located between Mars and Jupiter.

Basing on their composition Asteroids are divided into-C Type, S Type, and M Type. The C-type asteroids are consist of clay and silicate rocks and are dark in appearance. The S-types are made up of silicate materials and nickel–iron, also known as stony Asteroids. The M-types are metallic, composed of primarily nickel and iron. The composition of the asteroids vary in wide range. Aside from the above three types, some contain an Icy crust. All the 3 types of asteroid can be used in this process. The order in which they will impact will change as we move ahead in the Terraforming process.

Their impact order should be:

1. M-types
2. S-types
3. C Type

We have to deflect asteroids to strike the target planet at specific intervals to stimulate necessary planetary conditions for human habitation. To do this we can use Solar Sail technology. We send number of solar sails to the nearest asteroid belt. Solar sails will attach themselves to the asteroid surface. Using suns radiation pressure they will push the asteroids in required direction.

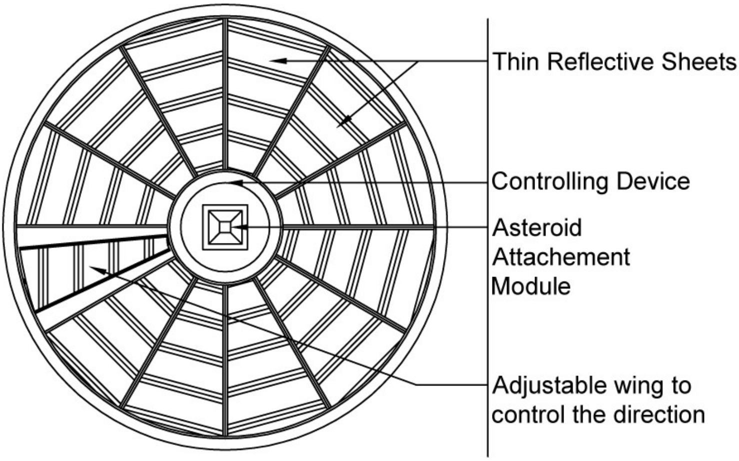

Thin Reflective Sheets
Controlling Device
Asteroid Attachement Module
Adjustable wing to control the direction

Figure-17.1, Model of a Solar Sail

The asteroids will be directed at the target planet to impact at pre-calculated intervals. When the asteroids strike the surface of the planet they will generate huge amount of energy and the process of remelting of the core will initiate. For this purpose we shall require S Type, and M Type asteroid to get the desired result. As these two kind of asteroid contain appreciable amount of metal they will partially burn in the thin atmosphere and impact with enough force to travel deeper parts of the planet.

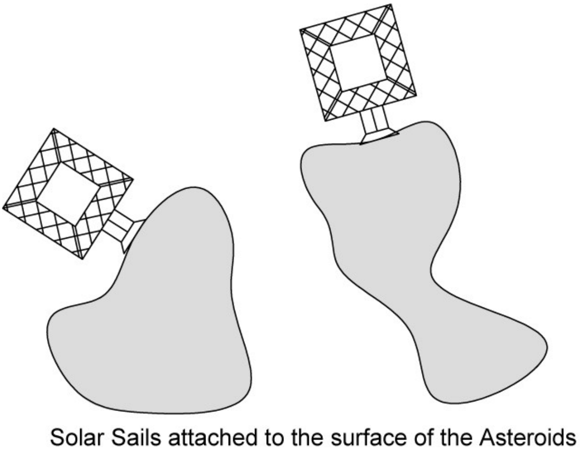


Figure-17.2, Attached Solar Sails to an Asteroid

❑As the asteroids hit the planet’s surface shock waves will generate from the point of impact and travel outwards. Surface waves will travel on the surface but P-wave and S-Wave will travel towards the interior of the planet.

❑When the P-waves travel through the lower mantle and Core, i.e. high pressure regions of the planet, the compression and rarefaction waves will change the instantaneous density of the medium for a short period.

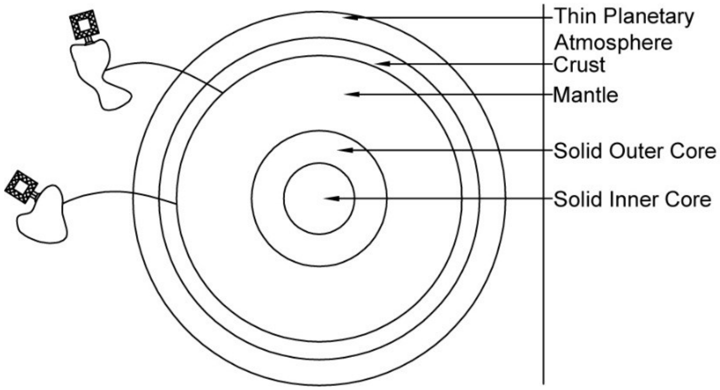


Figure-17.3, Solar Sails Dragging Asteroids towards the Planet

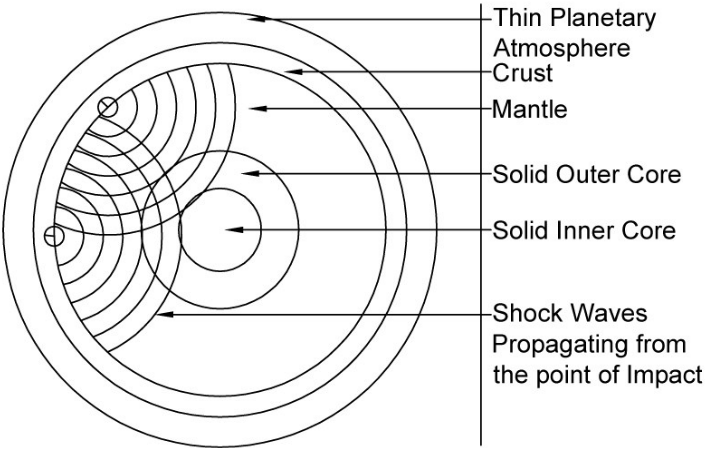

Thin Planetary Atmosphere
Crust
Mantle
Solid Outer Core
Solid Inner Core
Shock Waves Propagating from the point of Impact

Figure-17.4, Shock waves generated due to Impact of Asteroids

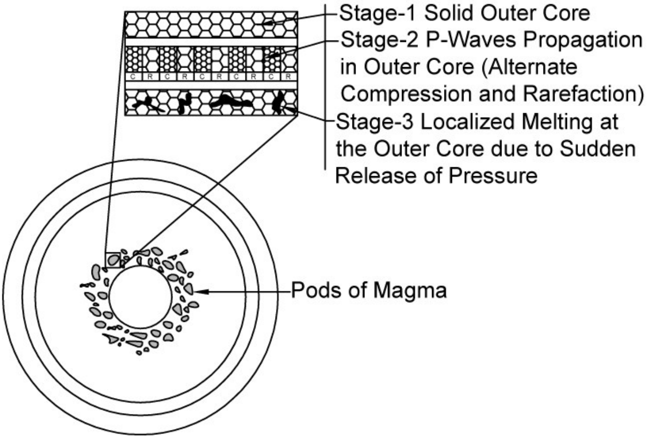

Stage-1 Solid Outer Core
Stage-2 P-Waves Propagation in Outer Core (Alternate Compression and Rarefaction)
C R C R C R C R C R
Stage-3 Localized Melting at the Outer Core due to Sudden Release of Pressure
Pods of Magma

Figure-17.5, Localised melting at the outer core

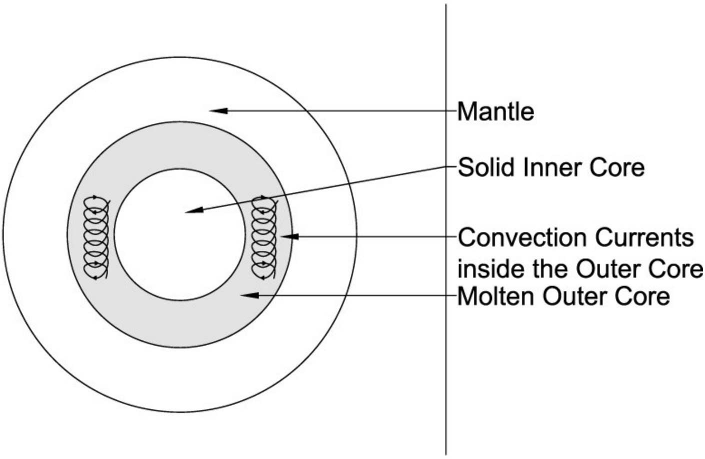


Figure-17.6, Partial Melting leads Complete Melting of Outer Core

❑ Due to sudden release of pressure by rarefaction, chunks of matter at lower mantle and outer core will start to melt. As the compression reaches this molten mass will be squeezed out via inter-granular space and segregate below the lower mantle.

❑ With repetition of this process molten rock mass will be accumulated just outside the high pressure zone. Once the molten mass accumulates, it will start to assimilate adjacent rocks and form a molten outer core.

❑ When the process of liquid outer core formation completes, convection currents will start inside the outer core similar to earths, due to compositional and temperature difference.

❑ This convection current will generate electricity and associated magnetic field and the planet will regenerate its own magnetosphere.

Using this method we can restart the Geodynamo of a planet. As the energy generated from the shock waves remelt the core of the planet, the molten mass will start the convection of materials and generate planetary magnetic field. The planet protected from solar and cosmic radiation will be habitable for humans.

Chapter-18

Impact Rejuvenation

The giant impact hypothesis suggests that Moon was formed by the collision event between Earth and a Mars sized planetesimal approximately 4.5 billion years ago. The colliding body is called Theia. The debris generated from this impact was blown away from earth. The orbiting debris around earth assimilated due to force of gravity forming Moon.

Mars is an inhabitable planet because of its thin atmosphere composed mostly of CO2, low surface gravity, no magnetosphere and many other reasons. But before 4.5 billion years ago it had an oxygen rich atmosphere, hydrosphere and may be a biosphere. Because of consecutive asteroid impacts during the period 4.5 to 4 billion years Mars lost its atmosphere and magnetosphere, it has turned inhospitable to life forms. Remaining life forms may have gone extinct or migrate to subsurface.

Two third of earth’s surface is covered with water. Water is the basic requirement of all life forms on earth. It is considered that water on earth is accumulated from volcanic eruption and condensation of water from the primordial atmosphere. Many scientists suggest that all the water on earth has not accumulated insitu, but are of extra-terrestrial origin. They had brought to the earth in form of icy asteroids and meteorites. The main asteroid belt of early solar system may have brought water to the world's oceans.

Past asteroid impacts has shown, that they are the cause of mass extinction of many species and abrupt climatic and geological changes on Earth.

Asteroid impact is the reason of many extinction events on Earth. The most known among them is the Bolide impact approximately 66 million years ago causing Chicxulub impact crater. As the result of the impact huge amount of dust particles and heat was generated. These changes in climatic condition of earth lead to extinction of dinosaurs.

As a result of impact massive amount of dust was thrown out to the upper atmosphere of Earth causing the drop of atmospheric temperature obstructing the incoming solar radiation and initiating Ice ages. During those Ice ages many surface and marine life forms became extinct.

Deccan trap is one of the largest volcanic features on Earth. It was formed 60 to 68 million years ago i.e. towards the end of Cretaceous period. This volcanic lava flow continued for the period of 30,000 Years emitting volcanic dust, gases and Sulphur Dioxide causing huge climatic and geological changes on the surface of Earth.

Some scientists suggest it was related to Chicxulub impact event in Central America. It played a major role in the Cretaceous-Tertiary Extinction event.

Impact events have shaped earth's geological and biological elements from time to time. Impact played a major role in evolution and origin of life. According to some, life on earth has not originated here but has been transported from planet to planet inside asteroids and meteors. This view on origin of life known as Panspermia, is still a debate for scientists.

We know the devastating effect of asteroid impact. But we cannot deny the hidden role of impact events in shaping the process of evolution leading to origin of humans. Without extinction of dinosaurs humans could not have sustained on earth. Impact events not only change the Surficial but the planets interior structure and mechanism.

Impact Rejuvenation is the process by which we can Terraform a planet or make it earth like habitable place for living organisms. Controlled and timely collision of asteroids on a planet can change its fate and make it habitable.

Considering the case of Mars or any other planets of some anonymous solar system, impact of asteroids can change the fate of the planet entirely.

Natural resources and the atmosphere of Earth are at a constant degrading stage. For mankind to survive we have to search for other planets which are habitable. Planets with geological and environmental conditions similar to Earth are habitable. Life on Earth is possible because of the availability of water, magnetic field generated by inner Core which protects us from harmful solar radiations and enough gravity to hold the atmosphere. Also physical and chemical composition of atmosphere, hydrosphere and lithosphere are necessary. Still humans can live with variation of these parameters within a limit.

Humans need a specific atmospheric composition but for years we have been experiencing change in atmospheric parameters, still we are alive and growing. Humans are very susceptible to gravity. As we born and grow experiencing earth's gravity, living in space is terrible experience for us. Future humans will have to travel to other planets and space travel will be a normal activity for them. Someone born in low gravity conditions may not like earth's gravity. With time humans will evolve and get acquainted to the change in environmental conditions. But this process is slow and may take a long time for humans to evolve, for living in low gravity and low oxygen environment.

If we find a planet with similar conditions like earth, human habitation will be possible there. It is possible, a planet with low gravity compared to earth has a thin atmosphere, with subsurface or polar storage of water in form of ice but the planet may not have its own magnetosphere to protect the planet. Origin and evolution of life on that planet will be difficult due to periodic solar wind and cosmic radiation.

We can consider this as a case of Mars. It has the necessary conditions we are searching for Low gravity, carbon dioxide rich atmosphere, polar ice caps and no magnetic field. Mars has a very low surface gravity, value of g on Mars' surface is 3.711 m/s^2. Mars atmosphere composed of 95% carbon dioxide, Water stored in form of Ice in polar and subsurface regions. Mars does not have a magnetic field due to solidification of its iron core inside the planets interior. For these types of planets we can use methods of impact rejuvenation to bring back the planet to habitable condition.

For the process of terraforming on Mars sized planets we use Asteroids as tools of our experiment. The residual parts of early solar system evolution, known as asteroid are found in solar system, preliminarily at Asteroid belt between Mars and Jupiter. Another one clusters asteroids found in Kuiper belt outside Neptune. For this purpose we shall use asteroids from main Asteroid belt, located between Mars and Jupiter.

Basing on their composition Asteroids are divided into-C Type, S Type, and M Type. The C-type asteroids consist of clay and silicate rocks and are dark in appearance. The S-types are made up of silicate materials and nickel–iron, also known as stony Asteroids. The M-types are metallic, composed of primarily nickel and iron. The composition of the asteroids vary in wide range. Aside from the above three types, some contain an Icy crust. All the 3 types of asteroid can be used in this process. The order in which they will impact will change as we move ahead in the Terraforming process.

Their impact order should be:

4. M-types
5. S-types
6. C Type

They will respectively Generate intense Shock Waves, Huge amount of heat and energy and add matter to the planets mass. We have to deflect asteroids to strike the target planet at specific intervals to stimulate necessary planetary conditions for human habitation. To do this we can use solar sail technology. We send number of solar sails to the nearest asteroid belt. Solar sails will attach themselves to the asteroid surface. Using suns radiation pressure they will push the asteroids in required direction.

The asteroids will deviate from their path and head straight to Mars. With controlled asteroid impact at desired interval we can make Mars habitable. Starting from the impact the following events will take place respectively to reform the planet.

❑The impact of asteroids on the planet will not only affect its surface, the shock waves will propagate to the core of the planet. If asteroids are large enough, they will generate high energy shock waves. These shock waves will disturb the equilibrium of the core.

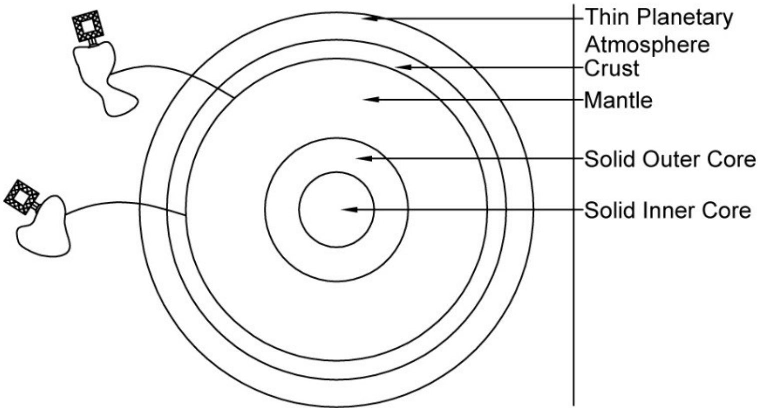


Figure-18.1, Solar Sails Dragging Asteroids towards the Planet

❑ Parts of the incoming asteroids and meteorites will burn in the atmosphere and produce huge amount of dust, with increasing number of asteroids entering the atmosphere it will grow denser. Residual parts of the asteroids will collide with the planet generation huge amount of heat, dust and shock waves.

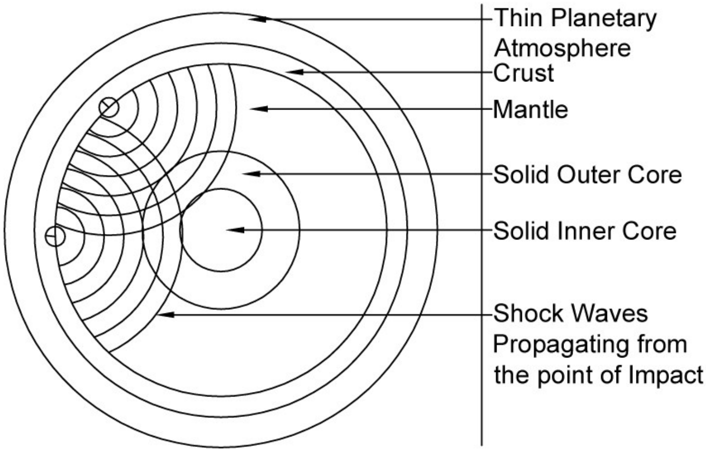

Thin Planetary Atmosphere
Crust
Mantle
Solid Outer Core
Solid Inner Core
Shock Waves Propagating from the point of Impact

Figure-18.2, Shock waves generated due to Impact of Asteroids

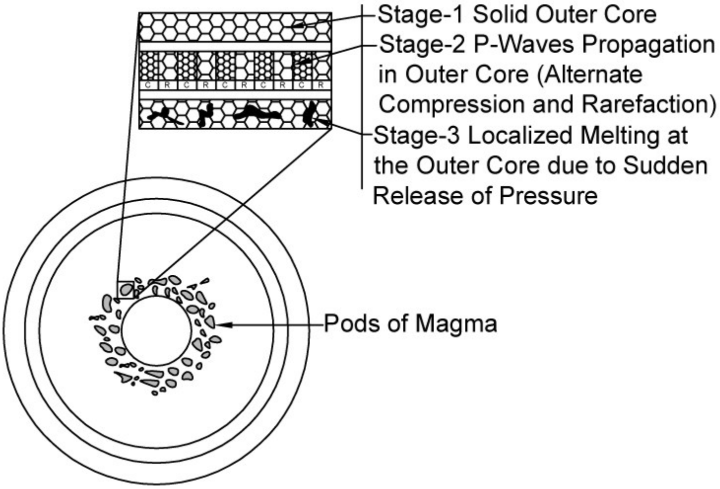

Stage-1 Solid Outer Core
Stage-2 P-Waves Propagation in Outer Core (Alternate Compression and Rarefaction)
C R C R C R C R C R
Stage-3 Localized Melting at the Outer Core due to Sudden Release of Pressure
Pods of Magma

Figure-18.3, Localised melting at the outer core

❑From the point of impact longitudinal waves, the P-waves will travel towards the interior of the planet. While their passage through the lower mantle and Core, i.e. high pressure regions of the planet, the compression and rarefaction waves will change the instantaneous density of the medium for a short period.

❑Due to sudden release of pressure by rarefaction, chunks of matter at lower mantle and outer core will start to melt. As the compression reaches this molten mass will be squeezed out via inter-granular space and segregate below the lower mantle.

❑With repetition of this process a layer molten rock mass will be accumulated outside the high pressure zone of core, below the lower mantle. Once the molten mass accumulates, it will start to assimilate adjacent rocks and form a molten outer core.

❑As the process of liquid outer core formation is complete, convection currents will start inside the outer core similar to earths, due to compositional and temperature difference. This convection current will generate electricity and associated magnetic field and the planet will regenerate its own magnetosphere.

❑Due to addition of mass by the asteroids Mars' mass will increase so as its gravity. So the planet will be able to hold a denser atmosphere.

❑Impact will generate enormous amount of heat and dust which will envelop the planet. This may result remelting the Crust of the Planet. Because of sudden crustal disturbance and increased atmospheric temperature all the subsurface and polar ice caps will melt and flow on the surface.

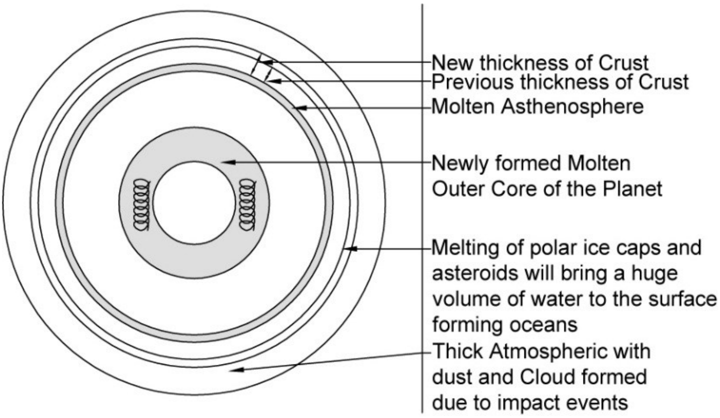

New thickness of Crust
Previous thickness of Crust
Molten Asthenosphere
Newly formed Molten Outer Core of the Planet
Melting of polar ice caps and asteroids will bring a huge volume of water to the surface forming oceans
Thick Atmospheric with dust and Cloud formed due to impact events

Figure-18.4, Habitable Planet as a result of Planetary Rejuvenation

❑As the atmospheric pressure and density has increased the molten ice will form huge oceans on the planet's surface. Due to dense atmosphere surface of mars will be protected from solar radiation and the water vapours will be trapped inside the planet's atmosphere.

❑Liquid water on the surface will initiate hydrologic cycle as it will evaporate and precipitate. As the planet is now a closed system this process will continue for a long period.

❑As Mars is far from Sun, so it will receive lesser amount of solar radiation and cool faster compared to its core. After a period of precipitation and atmospheric turbulence, planet's atmosphere will be cleared from dust particles.

❑Resulted planet will have higher mass compared to Mars, therefore higher surface gravity, dense Atmosphere, a liquid Hydrosphere and active Magnetosphere.

This method of Terraforming is applicable to planets of Mars' size, because for much larger planets the impact force will not reach deep enough to melt the core. These changes on mars may not make it habitable for humans, but many unicellular organisms on earth may survive in the newly formed planet. The resulted planet after Impact rejuvenation will have higher Surface Gravity, Planetary Magnetic Field, Liquid Hydrosphere and Dense Atmosphere. Using the methods of Impact Rejuvenation we can terraform any Mars' size planet.

Chapter-19
Reflecting Satellite Station

As we move away from the central star of a solar system, incoming radiation flux decreases, causing temperature variation at various intervals. So planets close to the Sun of the solar system experience more incoming heat. As for example Planet Mercury and Venus has higher surface temperature compared to other distant planets. We can say, that before the Circum-planetary habitable zone, the planet's surface temperature remains high and thus the planets become uninhabitable.

Amount of solar radiation received by a planet depends on following parameters:

- ❑Distance of the planet from sun
- ❑Size of the planet
- ❑Intensity of the solar radiation
- ❑Albedo Value
- ❑Atmospheric conditions of the planet

Some planets compensate the low intensity of incoming solar radiation by holding the sunlight. Increased temperature in distant terrestrial planets is the result of greenhouse effect. For the planets inside habitable zone surface temperature will be enough for existence of life. But While inside or outside the habitable zone planets are uninhabitable because of extreme high or low surface temperature. Planets at the boundary of solar system become ice world as they receive very low heat from the central star.

Planets close to sun will have very high surface temperature characterized by absence of liquid water, volatile rich atmosphere, high atmospheric temperature and pressure, which will not support any life forms on the planet. On the other hand planets distant from the star of the solar system will be frozen, may be icy planets. In absence of H_2O, there will be frozen planets with hydrogen, methane or ammonia rich atmosphere.

Albedo or also known as Bond Albedo is the reflecting power of a planetary surface. It is the ratio of reflected radiation from the surface to incident radiation upon it and is measured on a scale from zero for no reflection of a perfectly black surface to 1 for perfect reflection of a white surface. Below is a table showing solar system planets, their distance from sun, intensity of incidence light and Bond Albedo.

Planet	Distance from Sun (AU)	Intensity of light (% of earth's)	Bond Albedo
Mercury	0.387	667.7%	0.119
Venus	0.723	191.3%	0.75
Earth	1	100.0%	0.306
Mars	1.523	43.1%	0.25
Jupiter	5.202	3.7%	0.343
Saturn	9.538	1.1%	0.342
Uranus	19.181	0.3%	0.3
Neptune	30.057	0.1%	0.29

Table-19.1, Albedo value of Solar System Planets

So Albedo value for each planet of the solar system will vary depending on the texture of the planetary surface. Atmosphere of the planet also plays an important role in controlling value of Albedo, like on earth Albedo varies depending on cloudy sky, ocean surface or snowfall regions. Texture of the planetary surface may vary depending on planets internal changes and position around the sun. The incoming radiation for different planets is different depending on distance from sun.

In above table we can observe intensity of incident sunlight decreases for planets depending on the distance of the planet from sun, while Bond Albedo varies independently. It is observed though Venus receives twice intensity of sunlight but the Albedo value for Venus is much higher than Earth. Which means Venus's surface reflects nearly 75% of incident solar radiation. But the small amount of absorbed heat by Venus makes the planet a volcanic and hostile environment.

On Earth about 29 percent of the solar energy that arrives at the top of the atmosphere is reflected back to space by clouds and atmospheric particles. This energy plays no role in Earth's climate system. About 23 percent of incoming solar energy is absorbed in the atmosphere by water vapour, dust, and ozone, and 48 percent passes through the atmosphere and is absorbed by the surface. Thus, about 71 percent of the total incoming solar energy is absorbed by the Earth system.

For life to thrive and evolve suitable temperature is necessary which is related to the Albedo value and intensity of incident sunlight on the planet i.e. the planetary temperature is controlled by incident sunlight. So to sustain life or Terraform a volcanic or frozen planet we have to control the surface temperature of the planet. This can be done by reflecting the solar radiation away from the planet or by directing extra solar heat to the planet.

As the surface temperature of the planet largely depend on the incoming solar radiation, large aperture mirrors can make a difference reflecting away unnecessary sunlight or heat. For building such huge mirrors, we have to send parts of these mirrors to space and put them in orbit around the planet. These arrangements should be flexible so that we can increase or decrease the area and direction of reflection according to our requirement. Given below is a model of reflecting mirror which can be used for same purpose.

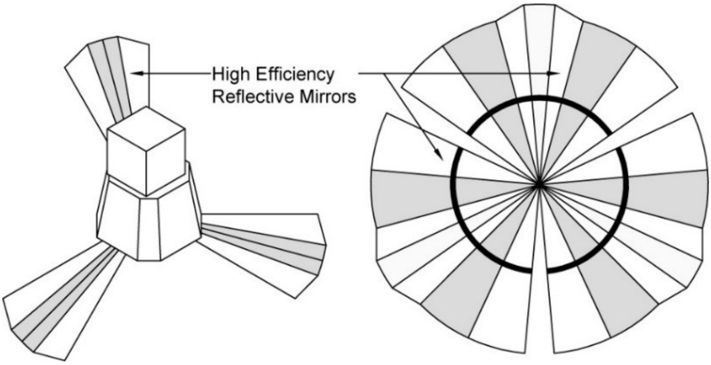


Figure-19.1, Solar Radiation Reflector Satellite

As we can see above it is s typical satellite with huge apertures of highly reflective material. One or number of these satellites can be sent to the orbit of the target planet. These satellites will orbit the planet in polar or geosynchronous orbits. The satellite contains number of folded highly reflective mirrors. The position and spread of these mirrors can be controlled. Depending on the position of the planet around the star we can change the amount of incident sunlight on the planet. These can also be used to increase the surface temperature of any planet for Terraforming purpose like melting polar ice caps or increasing surface temperature.

House hold mirrors have aluminium coating in their back. They reflect 90 percent of the incoming radiation. Some part of the radiation is lost due to absorption and diffraction. As this absorbed heat increase with time the mirror will melt eventually due to heat accumulation under the incident radiation.

So to reflect Sun light in space we have to construct a mirror with 99.9% of reflectivity. A high quality silver mirror can achieve 95% efficiency. Dielectric mirrors are glass or other substrates on which one or more layers of dielectric material are coated. A very complex dielectric mirror can reflect up to 99.999% of the light incident upon it, for a narrow range of wavelengths and angles. The new technology of mirrors show 99.9 percent efficiency, called distributed Bragg reflectors (DBRs). In these mirrors High reflectivity can be achieved with DBRs, in which light passes through alternating layers of aluminium gallium arsenide and gallium arsenide.

We can use the reflecting glasses according planets requirement. For planets close to the sun of the solar system the incoming heat flux will be high, resulting high surface temperature which will make it uninhabitable. With the help of reflecting satellite we can divert unnecessary solar radiation away from the planet, which will reduce the planet's surface temperature. The reflecting satellite will have to revolve around the planet in such a manner to obstruct the direct sunlight to hit planet's surface.

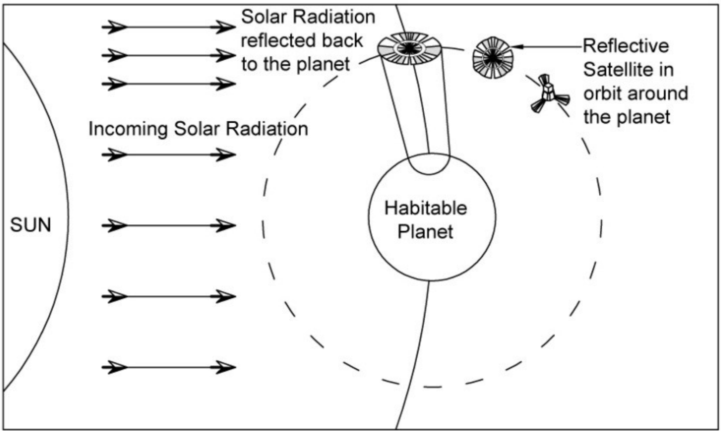

Solar Radiation reflected back to the planet
Reflective Satellite in orbit around the planet
Incoming Solar Radiation
SUN
Habitable Planet

Figure-19.2, Reflecting Satellite Stations controlling the Albedo value of the planet

As shown above number of Reflecting Satellite Stations revolve around the target planet. When the satellites come to right position they stretch their arms and unfold their mirrors. The mirrors spread and adjust themselves according to the direction of sun. They reflect desired amount of sunlight towards or away from the planet. If continued for a long period this process will be able to control the surface temperature of the planet.

Distant Planets, away from the habitable zone of the solar system are cold. Hence due to frozen surface it will be uninhabitable. Reflecting Satellite station orbiting close to the planet can increase the amount of solar radiation incidence on the planet. As a result planet's surface temperature will increase. If the method results in desired changes on the planet, we can make the planet habitable.

Chapter-20
Green House Effect

The Earth receives energy from the Sun in the form UV, visible, and near IR radiation, most of which passes through the atmosphere without being absorbed. About 70% of solar radiation is absorbed by the planet. From which 50% of the radiation is absorbed by the surface of the Earth. The rest is reflected back to outer space. The surface of earth absorbs the heat and releases it in far IR thermal radiation of longer wavelengths. The lower atmosphere of earth is denser, therefore most of this thermal radiation is absorbed by the atmosphere and re-radiated both upwards and downwards. Some of that radiation is again absorbed by the surface of Earth. This mechanism of trapping of solar heat is known as Greenhouse effect.

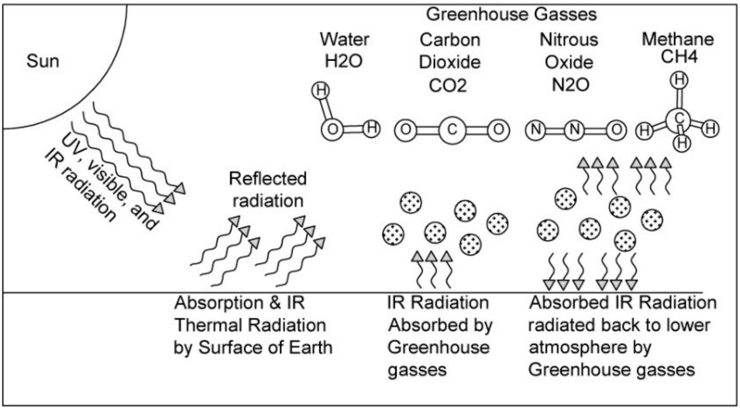


Figure-20.1, Greenhouse effect on a planet

Depending on the intensity of solar radiation coming from sun and distance of Earth, its surface temperature should be much below the current temperature. If earth had no atmosphere and it reflects 30% of incoming solar radiation its ideal surface temperature would be -18^0. So it is the greenhouse effect because of which human habitation is possible on this planet. The major greenhouse gasses on Earth are Water Vapour, Carbon Dioxide, Methane, Ozone, Nitrous Oxide (N_2O) and Chloro Fluro Carbons (CFC). Below given is a list of major greenhouses gasses on earth and their percentage in atmosphere. We can see that the major greenhouse gasses are also the major constituents of the Earth's atmosphere.

Major Greenhouse Gases	Contribution to Earths Greenhouse Gasses
Water vapour	36–70%
Carbon dioxide	9–26%
Methane	4–9%
Ozone	3–7%

Table-20.1, Volume percentage of Green House Gases

We may find a planet inside or close to the habitable zone of a Star and it is frozen or the surface temperature is much below the normal. It is also possible that the planet is going through an ice age. Ice age on a planet may have variable reasons. But small variation in atmospheric gas concentration can change the planetary heat absorption capacity, in turn it can trigger the end of Ice age.

Some atmospheric gasses absorb and radiate thermal Infra-Red radiation by increasing the holding time of incoming heat. The covalent bonding of greenhouse gas molecules bends and vibrates by absorbing the IR radiation. This absorbed energy is transmitted to other particles via kinetic energy and heat radiation.

Greenhouse gasses absorb heat because of their molecular structure. These gas molecules constitute of covalently bonded atoms. Inside every atom electrons orbit around the nuclei at specific "orbitals" and each of them correspond to an "energy level". Electrons move to a higher energy level by absorbing energy and radiate energy to come back to lower energy levels. Electrons get excited by absorbing energy form the environment, to come back to lower energy states it releases energy via electromagnetic radiation.

Major atmospheric gases such as Nitrogen, Oxygen and noble gas argon are not treated as greenhouse gasses, because monoatomic molecules have no net change in their dipole moment when they vibrate, hence are totally unaffected by infrared radiation. While carbon monoxide (CO), hydrogen chloride (HCl) etc. absorb IR radiation and radiate it back. But most of these gasses have a short period of residence in atmosphere. Hence Water Vapour, Carbon Dioxide, CFCs and few others are only regarded as greenhouse gasses.

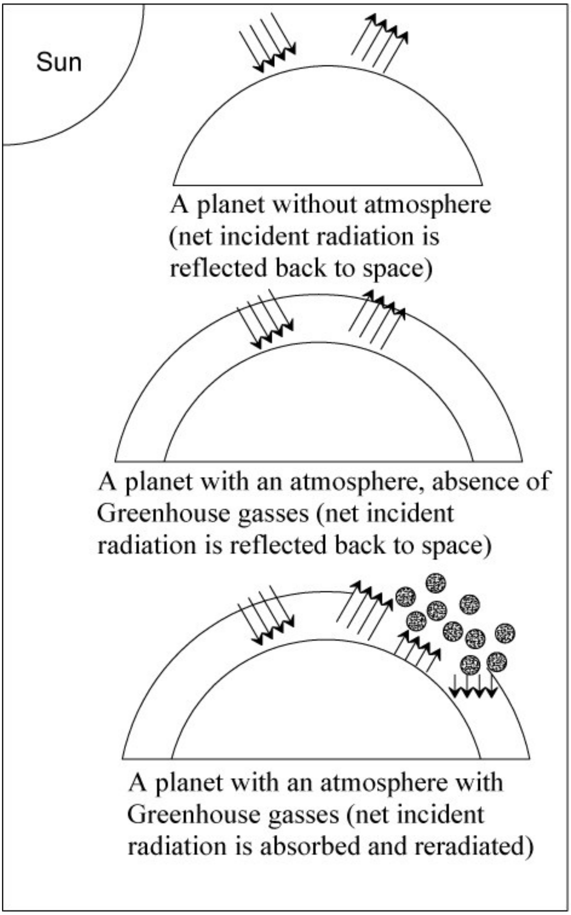

Sun
A planet without atmosphere (net incident radiation is reflected back to space)
A planet with an atmosphere, absence of Greenhouse gasses (net incident radiation is reflected back to space)
A planet with an atmosphere with Greenhouse gasses (net incident radiation is absorbed and reradiated)

Figure-20.2, Usefulness of Greenhouse gasses on alien planets

Above is a depiction of effect of solar radiation on planet's surface temperature. In the first picture, is shown a planet without an atmosphere. From the net incident solar radiation some will be absorbed and some will be reflected. Again the surface will radiate heat or IR radiation, which will escape to outer space due to absence of atmosphere to hold the heat. So the planet's surface temperature will be lower and it will be uninhabitable for humans.

In the second, shown a planet which have its own atmosphere but the atmosphere of the planet is lack of greenhouse gasses. In this case part of the incident radiation will be reflected back to outer space and the rest will be absorbed by the surface of the planet. But when the surface radiates the retained heat in form of IR radiation, there are no greenhouse gasses to absorb it. So the radiated heat will escape into space by convection of the atmosphere leaving a cold and deserted planet.

In both the above cases the planetary surface temperature will be much below human tolerance. But in third case we can see the incoming solar radiation is absorbed by the surface of the planet and re radiated. The radiated heat is again absorbed by Greenhouse gasses. Instead of being dissipated into outer space the heat is captured by the atmosphere which results in increased planetary surface temperature.

So from the above we can see the usefulness of greenhouse gasses. In our search for Terraformable planets we may find such cold planets which have negligible amount of greenhouse gasses in its atmosphere. To make such planets habitable we have to input greenhouse gasses into the atmosphere. Some greenhouse gasses like Carbon Monoxide and Methane can be found in neighbouring planets or can be produced on the planet. There are various methods to produce Greenhouse gasses insitu. Burning hydrocarbons and any other carbon compound we can generate Carbon Dioxide and Monoxide. Available source of Nitrogen and Carbon can be oxidised to get few greenhouse gasses. We can use icy meteorites as source of water for producing water vapour. In some planets water is stored in polar and subsurface regions inform of ice. We can easily get water vapour on those planets by vaporizing these ice caps in Polar Regions. Nuclear explosion or Reflecting Satellite Station can be helpful in such cases to melt the frozen water.

Greenhouse gasses will absorb the incident solar radiation and trap it for longer time period. As a result even if the planet is outside the habitable zone it will stay warm due to greenhouse effect. The little amount of sunlight entering the atmosphere will be circulated without being dissipated into space. So we can control the atmospheric temperature by controlling the amount of greenhouse gasses in the atmosphere.

Chapter-21
Parasitic Terraforming

In future, with new technological advancements we will be able to travel to distant solar systems. There is no guaranty that we will find habitable planets for humans. So we have to Terraform them according to our requirement.

Availability of habitable planets around a star depends much on the type of the star i.e. size, luminosity and age of the star. Some stars show high solar flare activity, conditions not favourable for near about planets to sustain organic life. If the planets are far away from the habitable zone or have lost their atmosphere, life may not be possible on those planets.

In these conditions we may find planets with trace or no atmosphere caused by its dissipation into space. So without atmosphere the low pressure on the surface of the planet will cause absence of liquid water on the planet and uninhabitable conditions for humans.

For these kinds of planets other conditions being the same i.e. if the planet has surface or subsurface reserve of ice or water and have enough surface gravity for human habitation we cannot abandon the planet. We have to replenish the planetary atmosphere.

Parasitic Terraforming is the method of manipulating atmosphere of a planet by adding atmospheric gasses. We have to refill the atmosphere of the Terraformable planet to make it breathable. First we have to analyse the present residual atmosphere for its composition and required atmospheric gasses. Below is a standard composition of earth's atmosphere.

Major constituents of air		
Gas		Volume in %
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbon dioxide	CO_2	0.0360
Neon	Ne	0.0018
Helium	He	0.0005
Methane	CH_4	0.00017
Water vapour	H_2O	0.001%–4%

Table-21.1, Composition of Earth's atmosphere

The second step in this process is to locate the sources for filling the planetary atmosphere. Nearest planets which are uninhabitable are the places for looking.

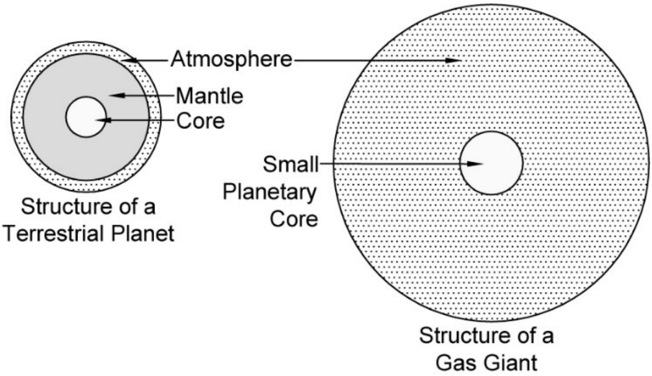


Figure-21.1, Structural Comparison of Gas Giants and Terrestrial Planets

There are gas giants like Jupiter and Saturn in every solar system which can provide with necessary atmospheric gasses. Some gasses are to be extracted from the dissociation of these gasses. Voluminous amount of gas has to be collected from these planets with giant Gas suckers. Below is a model of Planetary Atmosphere Sucker, which will collect necessary gasses from Gas Giants of a Solar System.

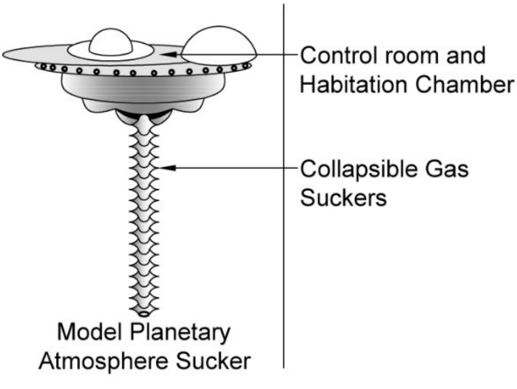


Figure-21.2, Planetary Atmosphere Sucker

And then this compressed air is to be released on the surface of the target planet. Below is a list of planets and their abundant atmospheric gasses can be used for Terraforming.

Planet or Satellite	Atmospheric Gasses
Jupiter, Saturn & Uranus	Hydrogen (H), Helium (He)
Europa & Ganymede	Oxygen (O2)
Titan	Nitrogen (N2)

Table-21.2, Compositions of some Gas Giants of solar System

For Water or Ice we will have to depend on asteroids. Icy meteorites and some asteroids contain huge reservoir of ice. We have to capture them for our requirement and extract the necessary materials.

Inert Gasses do not undergo chemical reactions under normal atmospheric conditions. Some inert gasses are used in scuba diving and deep water diving expeditions mixed with oxygen rather than Nitrogen. Purified argon gases are most commonly used as inert gases due to their high natural abundance (78% N2, 1% Ar in air) and low relative cost. Helium is used as a component of breathing gases to replace nitrogen, due its low solubility in fluids, especially in lipids. So of all atmospheric gasses Nitrogen, Argon and helium can be used as atmosphere of any deserted planet which will not react with other minor gasses. Also these gasses are non-greenhouse gasses so later we can input greenhouse gasses as per our requirement.

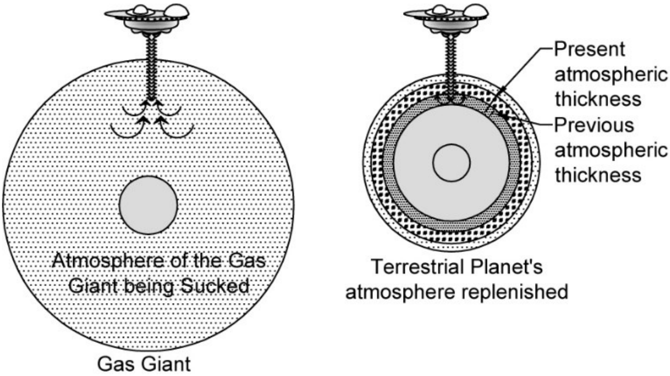

Present atmospheric thickness
Previous atmospheric thickness
Atmosphere of the Gas Giant being Sucked
Terrestrial Planet's atmosphere replenished
Gas Giant

Figure-21.3, newly formed Planetary Atmosphere

So the Terraformed planets atmospheric composition will be different from earths. Humans may have to wear gas masks if the required Oxygen concentration could not achieved. Below are some possible atmospheric compositions of Terraformed planet.

Planet	**Atmospheric Composition, Gases by volume Percentage**
Type1	Nitrogen:60, Argon:14.5, Helium:10, O2:15, CO2:0.5
Type2	Nitrogen:70, Argon:15, Helium:14, O2:0, CO2:1
Type3	Nitrogen:50, Argon:10, Helium:14, O2:25, CO2:1
Type4	Nitrogen:29.5, Argon:30, Helium:30, O2:10, CO2:0.5

Table-21.3, Compositions of newly formed planetary atmosphere

It will take years to build up an enough dense atmosphere for natural activities and human habitation, after atmospheric alteration we can live on the Terraformed planet as we live on Earth.

Chapter-22
Gas Dissociation Platforms

In a solar system we may find variety of planets. During our course of travel we may encounter a large star (5 to 10 time mass of our Sun) which has many terrestrial planets revolving around it. Mostly among terrestrial planets we have to search for similar to earth. Some those planets may have similar planetary composition with enough gravity and magnetosphere. But if the planets do not possess similar atmospheric composition like earth it will be uninhabitable.

Because planets with conditions similar to earth are very rare in the universe we have to Terraform the planet. The only thing required here is to transform the planetary atmospheric composition. On Earth Human breaths air which is a mixture of Nitrogen, oxygen, Argon, Water vapour and carbon dioxide. Our aim will be to bring the planetary atmospheric composition close or similar to this standard composition.

In every planet some of these gasses are available in free form or in compound with other element. We can change the atmospheric composition of the planet by doing the same we are doing on earth. Our industries, vehicles and fossil fuel use are changing the actual ratio of atmospheric compounds. We have to do the same on the distant planet.

Below is a list of solar system planets, dwarf planets and some satellites with their major atmospheric gasses:

Planet/Satellite/ Dwarf Planet	**Major Atmospheric constituents**
Venus	Carbon Dioxide, Sulphuric Acid
Earth	Nitrogen, Oxygen, Carbon Dioxide, Argon
Mars	Carbon Dioxide, Nitrogen, Argon
Jupiter	Hydrogen, Helium
Io Satellite of Jupiter	Sulphur Dioxide
Europa, Ganymede Satellite of Jupiter	Oxygen
Callisto Satellite of Jupiter	Carbon Dioxide, Oxygen

Saturn	Hydrogen, Helium
Titan Satellite of Saturn	Nitrogen, Methane
Uranus	Hydrogen, Helium, Methane, Ammonia
Neptune	Hydrogen, Helium, Methane
Pluto	Nitrogen, Carbon Dioxide, Methane
Makemake and 2007OR10	Nitrogen, Methane and Ice

Table-22.1, Major Atmospheric Gases of Solar System Planets

Above is a list of some solar system bodies and their major atmospheric gas composition. We can see the common atmospheric compounds in most of the planets. This suggests that the atmospheric composition of solar system objects vary with a pattern. Among the Planets we shall find in different solar systems, we can Terraform only the terrestrial or rocky planets. These kind of planets may have major constituents of atmosphere as Carbon Dioxide (CO_2), Sulphur Dioxide (SO_2), Nitrogen Oxide (NO) or Dioxide (NO_2), Methane (CH4) or Ammonia (NH_3). Mars and Venus' atmosphere composed primarily of Carbon Dioxide (CO_2) and Sulphur Dioxide (SO_2) respectively. Some terrestrial planets with carbon rich atmosphere may contain Methane (CH_4).

Huge gas processing chambers are to be established on such planets to process the air of the planet. Below is a model of gas dissociation platform for purifying and recycling the atmosphere of a planet.

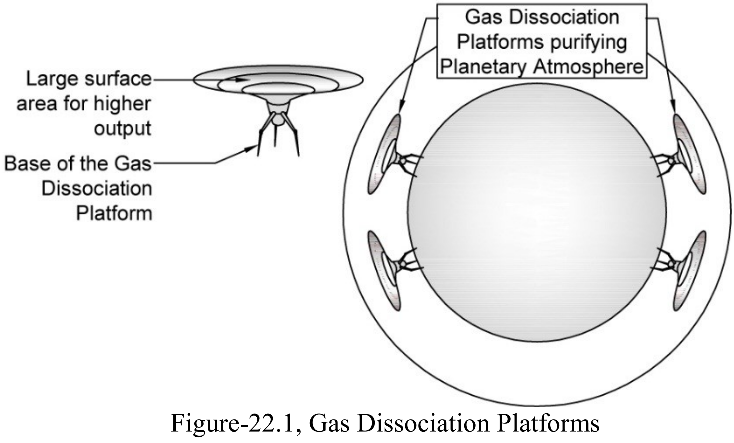

Gas Dissociation Platforms purifying Planetary Atmosphere
Large surface area for higher output
Base of the Gas Dissociation Platform

Figure-22.1, Gas Dissociation Platforms

In carbon dioxide carbon and oxygen are bonded by very strong covalent bonds. The amount of energy required to directly break the bond is too high. The process is carried out in a series of reactions via indirect methods.

Dissociation of Carbon Dioxide (CO_2) and Methane (CH4) has to be performed on the Terraformable planet to transform the planetary atmosphere for human habitability. There are number of methods for accomplishing the task, below described some of them for transforming the toxic planetary atmosphere.

CO_2 Dissociation:

Magnesium is burned in presence of air and oxygen to produce Magnesium Oxide.

$2Mg(s) + O_2 (g) \rightarrow 2MgO(s) + energy$

This process is exothermic. But once the process starts, in presence of carbon dioxide Magnesium starts to burn without oxygen forming Magnesium Oxide and Carbon.

$2Mg(s) + CO_2 (g) \rightarrow 2MgO(s) + C(s) + energy$

But in high energy conditions Magnesium oxide again reacts with carbon dioxide to produce magnesium carbonate.

$MgO + CO_2 + energy ---> MgCO_3$

$MgCO_3$ decomposes to magnesium oxide and carbon dioxide, this process is called calcining:

$MgCO_3 + energy ---> MgO + CO_2$

So the end product will be Magnesium Oxide and Carbon Dioxide i.e. that burning magnesium continues to burn in atmosphere of carbon dioxide.

$2Mg + CO_2 + energy ---> 2MgO + C$

After the Oxygen and Carbon has been differentiated we have to separate Magnesium from Oxygen and recycle this is carried out by the following process. Hydration of magnesium oxide produces Magnesium hydroxide.

$MgO + 2H_2O ---> Mg (OH)_2 + H_2 + energy$

$Mg(OH)_2 (aq) ---> Mg_2 + + 2OH-$

Oxidation At Anode:

$4 OH^-(aq) \rightarrow O_2(g) + 2 H_2O(l) + 4 e^-$

Though processing of Carbon dioxide is separated into carbon and oxygen. The water and magnesium produced are recycled.

CH_4 Dissociation:

Some planetary atmospheres are rich in Methane. To separate carbon from methane we use method known as steam reforming of methane, at high temperatures (700–1100 °C), steam (H2O) reacts with methane (CH4) in an endothermic reaction. This produces carbon monoxide and Hydrogen.

$CH_4 + H_2O \text{ ----> } CO + 3\ H_2$

Later additional hydrogen is generated through the lower-temperature, exothermic, water gas shift reaction, performed at about 360 °C. Oxygen is striped from water to oxidise CO to CO_2.

$CO + H_2O \text{ ----> } CO_2 + H_2$

After this the carbon dioxide generated is redirected to first stage and oxygen is separated from it. This cycle will continue spontaneously with very little supply of external energy.

It will take years but after a period of purification the planet will be ideal for habitation. As the Carbon percentage in the planetary atmosphere is reduced, so as the major Greenhouse Gases, the surface temperature will become tolerable in due course of time.

Chapter-23
Atmospheric precipitation

The kind of planets we shall encounter during our travel through the galaxy will be erratic. We may find a planet with dense atmosphere filled with unsettled dust particles and toxic gasses. The planet may have geological and atmospheric conditions similar to earth. But the atmosphere of the planet may contain high concentration of dust particles, as a result of asteroid impact and variable atmospheric gas composition. It may be in early earth condition and evolving slowly.

In such cases the atmospheric precipitation is a better way than recycling the air mass. If we find an earth like terrestrial planet we can use atmospheric precipitation to change the planetary surface conditions faster and make it habitable. We may encounter three types of conditions:

1. Water vapour available in the atmosphere i.e. clouds of H_2O available in upper atmosphere but temperature is too high for spontaneous precipitate.
2. Planetary atmosphere is rich in CO_2, SO_2 or NO_2 without water vapour.
3. Planet with high pressure and temperature conditions on the surface.

Precipitation occurs on earth when water vapour is carried by air to upper atmosphere. At high altitudes due to lower temperature water vapour starts to condense and forms tiny droplets of water. The size of these droplets increases by the processes of nucleation. Number of such droplets combines to form larger droplets, when the size exceeds 0.1mm they cannot be retained by the atmosphere and start to fall.

Sometimes the tiny droplets do not fall as their weight is below the threshold limit because of the unavailability of nucleation centres or unsuitable temperature. In such cases sprinkling the cloud with nucleating particles will induce raining. This process is known as cloud seeding. If the planet's surface temperature is not much different from earths, we can use Dry Ice (CO_2) or Silver Iodide (AgI) to cause nucleation induced precipitation or artificial raining. Minuit particles of salt or dust can also be used for providing nucleation.

In some planets the atmospheric temperature and pressure is too high as on Venus. The reasons are high incident solar radiation, higher volatile content in the atmosphere and low Bond Albedo value of the planets. In such planets we have to first reduce the surface temperature.

Reduced planetary surface temperature favours formation of `complex macromolecules which settle faster than independent molecule.

To make the atmospheric conditions favourable for human habitation we have to change both physical and chemical parameters of the planetary atmosphere. Artificial raining on the planet is the first step of atmospheric reshaping. As raining means on earth precipitation of drops of water, it may vary on other planets depending on the composition of the atmosphere. Precipitation does few changes in the atmosphere:

1. Clears the atmosphere from dust and floating minute colloidal particles.
2. Reduces surface temperature and starts to create a hard crust of the planet transforming depressions into oceans.
3. Dissolves or combines the volatile and evaporated chemicals.
4. Dissolves soluble salts in water and made nutrients available for primary life forms.

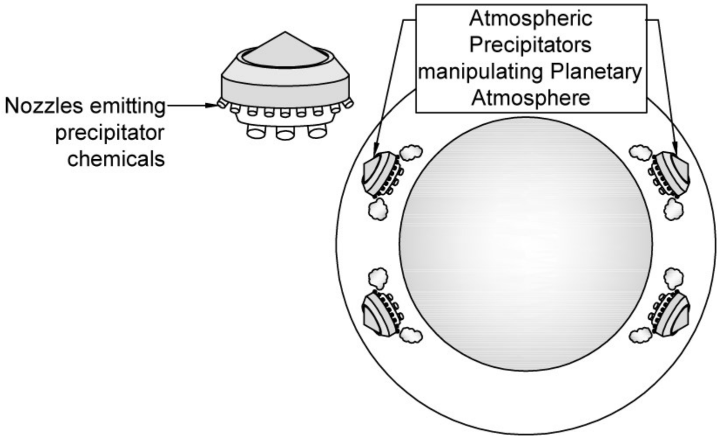

Atmospheric Precipitators manipulating Planetary Atmosphere
Nozzles emitting precipitator chemicals

Figure-23.1, Atmospheric Precipitator

Once temperature is reduces variable methods can be used to level the atmosphere. Example, sulphur can be precipitated using dust of Calcium carbonate ($CaCO_3$) or Calcium Oxide (CaO).

$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$

$CaO + SO_2 \leftrightarrow Ca\,(SO_3)$

And the by-product carbon dioxide can be separated to get oxygen. There are many other ways to clear the planetary atmosphere using chemicals for precipitation on the planet. We can use them to change the planetary atmospheric composition. This process of planetary atmospheric reconstruction will take a long time. But at the verge of leaving planet earth we may have to opt for this.

Chapter-24
Planetary Synthesis

Our solar system has originated from a hot giant nebula hurling in space after the big bang. But it was a cloud of dust and various gasses. The origin of solar system is explained by Nebular Hypotheses, which suggests, that there was a large, flat nebula spread beyond the most distant planet of solar system. Because of gravitational force and gas pressure the mass started to collapse towards the centre of the Nebula. The gaseous cloud rotated faster as the matter contracted, in a given time the outer rims achieved enough velocity to get detached from the original mass of nebula. The rings of gaseous cloud and matter were formed in space around the early Sun. Soon these rings condensed to form planetesimal.

Those dust and gaseous rings of matter left from the original nebula cooled and condensed to form small planetary bodies known as planetesimal. They collided with each other because of gravitational attraction and formed planets. The planetesimal, those could not form planets were captured by other planets or caught in an orbit around sun. The asteroid belt of our solar system is the group of planetesimal which could not form planet. Trans-Neptunian objects and Oort cloud are residuals of early nebular evolution.

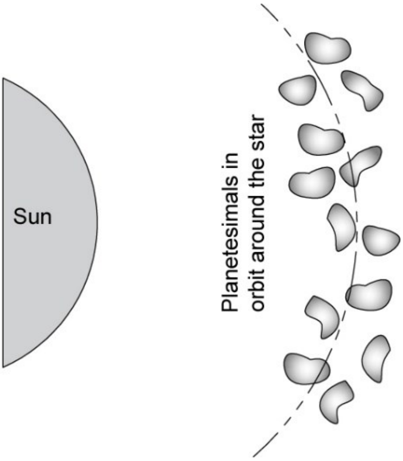


Figure-24.1, Planetesimal belt around the Central Star

During our journey through the Galaxies in search of Terraformable planets we may find a solar system where planetesimals were so small or apart that they could not form planets. Sometimes due to collision among themselves the planetesimals reduce in size. These smaller sized planetesimals do not produce enough Gravitational force to coagulate and form a planet. If we find the ring of planetesimal in or close to the habitable zone, we can accelerate the process of planetary synthesis for future habitation purposes.

Planetary Synthesis is the process by which we consolidate number of planetesimal to form a planet. If the planetesimals are made of rock forming minerals i.e. hard crust, with rich iron content it will be easier to bring them together. We have to start the process by uniting some of them the rest will be drawn together by gravitational attraction.

In such case a little stimulus in one direction can accelerate the fusion process. For the process of Planetary Synthesis major composition of the planetesimal should be magnetic material so that we can start the fusion chain by the use of magnetism, at the initial stage.

If the planetesimals are iron rich we can use magnetism to attract some of them to increase the fusion mass. As more number of planetesimals added to the mass the size and gravitational pull of the newly formed planet will increase. Then the rest of the planetesimal will be attracted to the larger mass due to gravitational pull.

If the planetesimals are nonmagnetic or made of silicate rocks we have to turn them into magnetic by attaching sheets of thin magnetic material. This can also be achieved by painting one side of the roaming planetesimals with iron or nickel dust mixed paint. Once the planetesimal gets enough mass to achieve a strong gravitational field, it will grow on its own.

For Planetary Synthesis our tool will be Planetary Synthesis Accelerator. An electromagnet i.e. PSA (planetary synthesis accelerator) is send to the orbit of the planetesimals. When the PSA reaches the orbit it stabilizes itself around the star in the same orbit as planetesimals. Then the electromagnet inside the PSA is activated. Soon it starts to behave like a magnet. It attracts near about magnetic debris and rushes towards a larger planetesimal. After reaching near the planetesimal it secrets an adhesive liquid, this binds the PSA and planetesimal together.

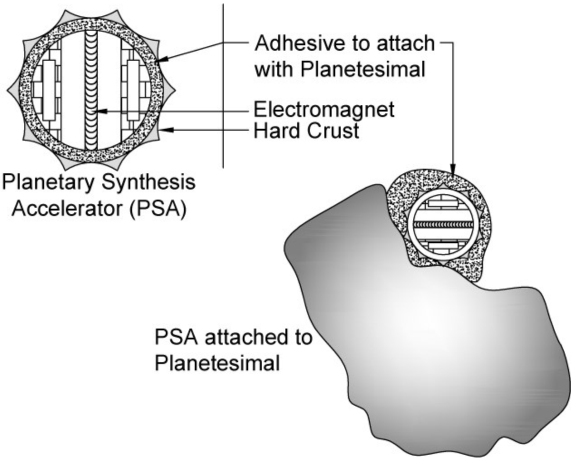

Adhesive to attach with Planetesimal
Electromagnet
Hard Crust
Planetary Synthesis Accelerator (PSA)
PSA attached to Planetesimal

Figure-24.2, PSA (planetary synthesis accelerator) attached to a Planetesimal

When we find that the PSA is attached to the planetesimal firmly, we increase the intensity of inner electromagnet. Soon magnetic debris and small sized planetesimal will be collected around it. As more and more mass is added to the primary planetesimal its size as well as mass increases many fold and it will attract more number of planetesimals. As a result the bulk will start to attain a regular shape and stronger gravitational field. Due to the force of gravity neighbouring smaller bodies will start to fall towards it. By that time the PSA has been crushed due to over burden pressure applied by the planetesimals.

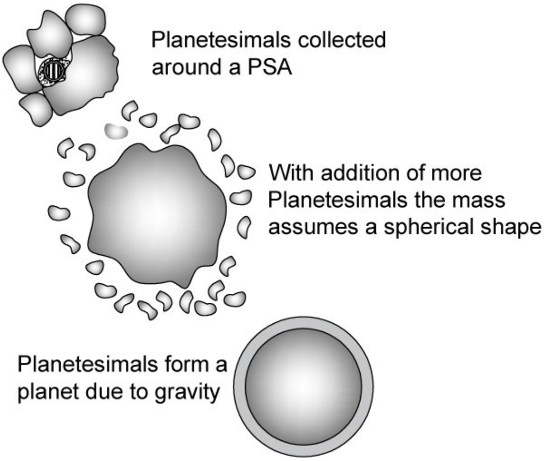

Planetesimals collected around a PSA
With addition of more Planetesimals the mass assumes a spherical shape
Planetesimals form a planet due to gravity

Figure-24.3, Planetesimals drawn together forming a Planet

But till that time when the PSA fails, the primary planetesimal has grown in size. It starts to gain a regular shape. Soon it envelops itself with an atmosphere of volatile matters and residual gasses. Terraforming with this method will take much longer than calculation, but we can use other methods to fasten the process. At the final stage of this process we can use Impact Rejuvenation to bring resources to the planet for human habitation.

In this way we can make a planet from the leftover planetesimals of a solar system. There are some assumptions which are to be considered prior to the process:

1. The planetesimals should be smaller size and they should be magnetic.
2. If they are not magnetic we have to magnetize them by either painting them with iron or nickel dust mixed paint or attach sheet of magnetic material to their surface.
3. If the planetesimals are larger size we have to consider using Impact Rejuvenation after primary stage of Planetary Synthesis.

Part-4: Environmental Adaptation

Chapter-25
Selective Habitation

Selective habitation does not include Terraforming or altering the planetary conditions, but it is a symbiotic or parasitic habitation on a planet. If we find that a planet's surface conditions are not favourable for human habitation instead of Terraforming we may search for favourable sites on the planet where most or some of our requirements are fulfilled by the planet. In Selective habitation we try to find regions on or inside the planet, where minimum habitation requirements are fulfilled and we mould ourselves to live on the planet.

Depending on the composition of the planet, distance from the central star and orbit around the star the surface conditions of the planet may vary widely. The planet may be uninhabitable in one season while in other times tolerable. In selective habitation we use the natural resources of the planet for habitation of humans.

For temporary settlement, we can live on a planet using its natural resources available on the planet as major tools for habitation, without affecting the planetary environment. Selective habitation can be treated as a branch of Paraterraforming. In Paraterraforming we had to depend mostly on outer resources while in selective habitation we use the concept of Paraterraforming but using most of insitu resources.

When we live on a terrestrial planet or satellite we can get some of our requirements from the planet. We can use the cratered surface of a planet as our cover from cosmic radiation and intense UV rays. Craters, Polar Regions and subsurface sedimentary rocks can be the source of water in many planets. Atmosphere of many planets contain required gasses Oxygen, Hydrogen, Nitrogen and greenhouse gasses. As per example for Cratered planets like Venus and Earth's Moon we can live inside craters, where we can be protected from solar radiation. On deserted planets like Mars we can live inside Underground Tunnels or near the polar region to get water from the ice caps. Habitable domes on surface can also be used for habitation.

Some planetary bodies are tidally locked with stars or Planets. In such cases one side of the planet is baked while the other side is dark and cold. But life can originate and evolve anywhere the universe. The twilight zone on such planets is the place, which is not too cold or too hot. Variation of distance from the star may be due to planets highly elliptical orbit, as a result environment of the planet may imitate summer and winter seasons of Earth. If such planets are inside the habitable zone and water is available on the planet it should be considered for habitation.

Depending on the surface conditions, we have to use one or many methods of Paraterraforming for building temporary settlement on the planet. In selective habitation we apply the principles of Paraterraforming, but for settlement we search for sites on the planets where some of our requirements are fulfilled. There are few extra-terrestrial conditions which can be chosen for settlement:

1. Artificial caves built on frozen Ice worlds
2. Subsurface Oceans of frozen Ice worlds
3. Deep Oceans of Water Worlds
4. Subsurface cavities and Polar Ice caps of Rocky Planets
5. Craters of terrestrial planets where we can find storage of Ice
6. Craters of terrestrial planets to get protection from solar and cosmic radiation
7. Far side or Twilight zone of planets for planets close to the central star
8. Dwarf planets polar regions for avoiding impact hazard and storage of Ice

There are some small sized satellites such as Europa, Titan and Castillo moons of Jupiter and Saturn have huge resources of water. But such satellites experience extreme surface radiation due to the powerful magnetosphere of master planets. In such planets we have to live below the thick icy lithosphere and use the available resources to live inside the planet. Below are few depictions of selective habitation on alien planets for human settlement:

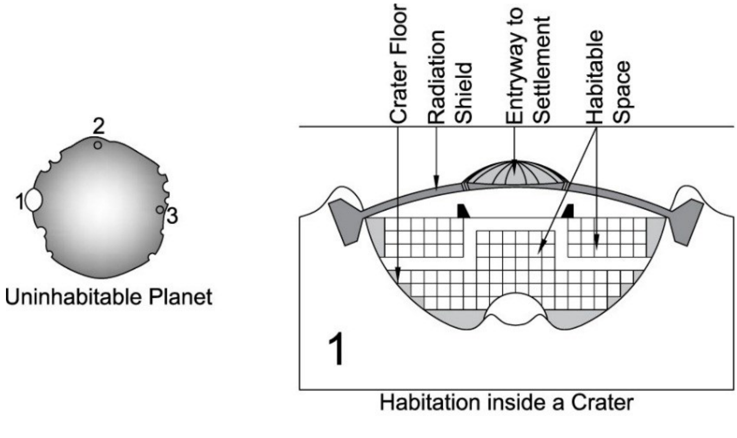


Figure-25.1, Cratered Planets with high radiation risk

The first case shown above is for planets, which are far from asteroid belt. Such planets are satellite of massive planets or themselves dwarf planets. These kinds of planets will experience lower asteroid impact but will experience high cosmic radiation. Magnetosphere of the parent or nearby planets will also affect the targeted planet. For living on such planets we have to choose craters and Polar Regions. Craters will provide better cover from cosmic and solar radiation. Some craters contain reservoir of ice at the bottom. By living inside a crater, we can avoid the high radiation flux incoming towards the habitation. We only have to cover the roof of the habitation for radiation shielding.

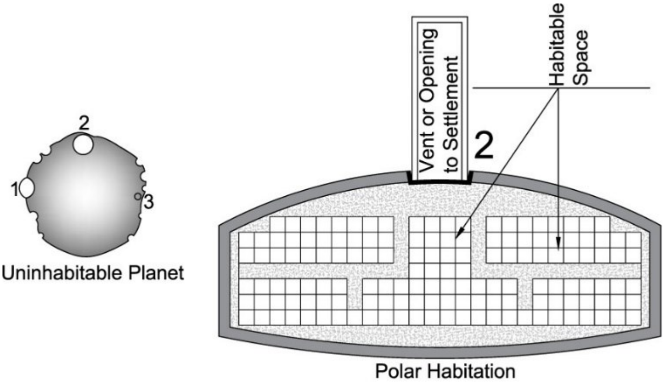


Figure-25.2, Planets with extreme surface temperature

The second case shown above is for deserted planets. These planets are close to the central star. They have a thin atmosphere and extreme surface temperature conditions. On such planets we have to live subsurface at higher depths near the Polar Regions to avoid high solar radiation and surface temperature.

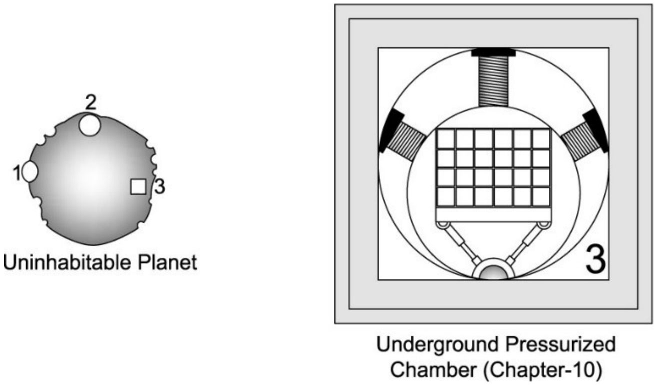


Figure-25.3, Planets close to Asteroid Belt

The third case shown above is for planets, which are close to asteroid belt or satellite of medium sized planets. These planets will experience high asteroid and meteor impact. These impacts will generate devastating shock waves and make the planet's surface uninhabitable. So to live on such planets we have to use Underground Pressurized Chambers (Chapter-10).

We can build habitable dome for short term and long-time habitation on deserted planets taking our surrounding environment into consideration. If the newly found planet is not Terraformable we can built temporary or long term settlement on the planet using the principles of Selective habitation.

Chapter-26
Microbial Plantation

Life originated on Earth as a unicellular organism, which was the simplest form of life. But gradually it evolved and affected the planetary atmosphere, hydrosphere and environment. As life evolves on a planet so does the planet itself. The theory of Panspermia suggests that life exists throughout the universe and it spreads from one planet to other.

Life originated on earth from the interaction among chemical soup spread on early oceans, earth's atmosphere, and sunlight. Since then life has travelled a long path. Unicellular organisms evolved to Multicellular organisms, plants and animals. With time life has learned to sustain in changing climatic conditions of the planet. On earth life is found in deep ocean trenches, ocean floor volcanoes, frozen hill tops, deserts and in highly acidic water. From this it is clear that given enough time life can evolve to any set of circumstance. If life can originate and evolve on earth why it cannot grow and evolve on other planets.

Astrobiologists name the organisms Extremophiles which can thrive in extreme environmental conditions. Such organisms can grow at several kilometres depth of oceans, near hydrothermal vents, highly acidic environment, ice, or boiling water. Some of these species seem to have evolved recently which can live inside salt crystals, toxic waste and near radioactive material.

This suggests that life can originate, grow and evolve under unfavourable conditions. So the planets considered as inhospitable by humans may be previously occupied by some unknown species of Extremophiles. The complexity of life on earth has changed the understanding and definition of life, how life may have evolved on a different planet.

Some organisms are able to withstand exposure of the vacuum and radiation of space example: the lichen fungi Xanthoriaelegans, the bacterium Bacillus Safensis, yeast Saccharomyces Cerevisiae, as well as the invertebrate animal Tardigrade and many others.

The environmental conditions we find on earth can be found in other solar system planets. So the organisms living there may sustain in the alien planetary conditions too. Below is a list similar environments found on earth and other planets.

Earths Environmental Conditions	**Planets with similar environmental conditions**
Desert (Low humidity and precipitation, Wide Temperature fluctuation, Dry land)	Mars
Arctic (Below zero surface temperature)	Jupiter’s moon Europa, Callisto
Surface Volcanic Environment (Lava flow with sudden release of energy, rock debris and trapped gasses)	Venus, Jupiter’s moon Io
Sub Oceanic Volcanism Environment (Lava flow with sudden release of energy and trapped gasses)	Jupiter’s moon Europa, Callisto
Fumaroles (Volcanoes emitting gases such as Carbon Dioxide, Sulphur Dioxide, Hydrogen Chloride, and Hydrogen Sulphide)	Venus, Jupiter’s moon Io
Deep Ocean Water (High pressure and low temperature environment)	Jupiter’s moon Europa, Callisto, Uranus’s Moon Ariel
Radiation Environment (Space environment, Cosmic and Solar Radiation or manmade radiation near Nuclear Reactors)	Mercury, Moon of Earth, Moons of Mars and Satellites of Jupiter, Saturn and Uranus
Toxic Atmosphere (Area close to Toxic waste dumping and processing factories)	Venus, Neptune, Triton moon of Neptune
Subsurface (High Lithostatic pressure and low oxygen environment)	Mars, Jupiter’s moon Ganymede
Anaerobic or Anoxic environment (Carbon Dioxide or Sulphur Dioxide Rich Atmosphere, low dense or absence of air)	Moon of Earth, Moons of Mars, upper atmosphere of Jupiter, Saturn and Uranus, Titan and Rhea Moons of Saturn

Table-26.1, Earth Environments Conditions on Extraterrestrial Planets

Moons of gas giant Jupiter and Saturn Europa, Castillo, Ganymede, Enceladus and Titan may have supported life forms inside them, deep in the oceans below the icy crust. For a long time we have considered Mars, geologically similar to Earth. It has a thin atmosphere, reservoirs of ice in its polar regions. It was found from the study of Martian meteorites that it can support bacterial life forms.

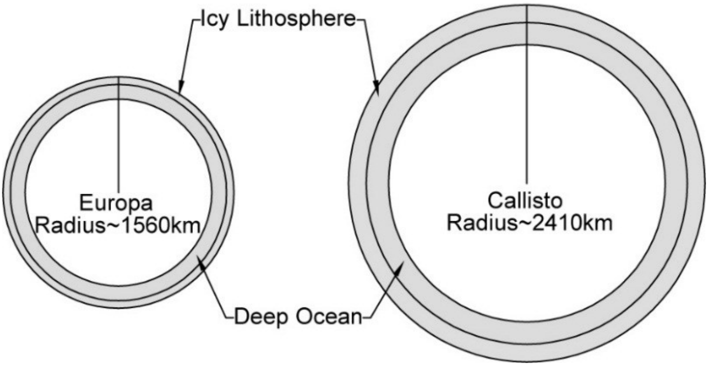


Figure-26.1, Frozen Satellite of Jupiter with deep subsurface Oceans, Possibilly nurturing alien life forms

Living cells contain many natural elements like hydrogen, oxygen, nitrogen, phosphorus, sulphur, and metals, such as iron, magnesium, and zinc, to provide the enormous diversity of chemical reactions necessary for a life activity. All the life forms found on earth are carbon based i.e. made of organic carbon molecules. Carbon is the most abundant element in living organisms, because of its bonding and capability of making long chain macro molecules. On the other hand silicon interacts with few elements and does not form long chain molecules. It was found from experiments that silicon can behave like carbon under different physiochemical conditions.

Whatever composition the Extraterrestrial life forms may be, it has a tendency to chemically alter its environment like on Earth. Living organisms live and grow consuming their requirement from the surrounding and alter the environment. The composition of earth's early atmosphere was very different from present, that it would be deadly for most of the evolved life forms to sustain and grow. Soon after the origin of life on earth about 4 billion years ago it started to spread on the ancient oceans. The life evolved and unicellular organisms became photosynthetic, multicellular, plants and animals. As the photosynthesis started on the planet its atmospheric composition started to change. The photo synthetic organisms used the carbon dioxide and water to make their food and produced a huge amount of oxygen. This oxygen later on due to UV rays in upper atmosphere formed Ozone. Ozone molecule screens out harmful ultraviolet radiation and prevents most of it from reaching the surface. Soon an ozone layer was formed to protect the surface dwelling organisms from suns UV radiation. Without an effective ozone layer in the upper atmosphere, more advanced life could not have emerged from the oceans to colonize the land.

The early atmosphere contained major amount of carbon dioxide. After the origin of life voluminous amount of carbon was sequestered in carbonate rocks such as lime stone, chalk, organic matter in soil and fossil fuel.

Now if we consider Mars or Venus, their atmosphere is rich in carbon dioxide just like earths early atmosphere and without the origin of life on earth it would have been the same.

So to Terraform an alien planet, which is not habitable for humans, we have to alter the atmosphere and environment gradually. The planet may have extreme environmental conditions, as found on Earth. In such case the organisms living on Earth under similar conditions can live on the targeted planet. So we plant some microorganisms or Extremophiles on the alien planet in their natural environment. These organisms will live and grow on the alien planet and evolve. Slowly these organisms will spread on the planet, for better results human interference will be required. They will consume and alter the planetary environment and atmosphere.

There are many organisms which can grow in extreme temperature and radiations conditions, below the surface at higher depth, near volcanic vents. We have discussed about such Extremophiles. Though humans cannot live on such planets such organism can grow and evolve, with them will evolve the planets environment. As the planetary atmospheric composition changes we can plant new species of organisms there to fasten the process of alteration of planetary environment.

Or we can make the necessary genetic changes in the organisms to fasten the process of evolution. By this process in shorter period we can achieve a desired planetary environment and number of new life forms adapted to it.

Chapter-27
Asteroid Spore Spreading

Life originated on earth 3.5 billion years ago. It started from a unicellular organism, then spread and evolved into many complex intelligent multicellular organisms. Scientists have different school on the origin of life on earth. Some believe that life originated on earth from non-living organic molecules floating on the Archean oceans while others believe that it has not originated here on earth but has come from some distant planet. Life as we see has originated on some distant planet and has spread to others. Some believe it has come from Mars. It is believed that earth is being infected with life by asteroids and meteorites. This view about origin of life is known as the Panspermia.

In the past unicellular organisms have overcome a number of natural disasters, extinction events and hostile environments and evolved to us, the final stage or the remnant of what is left. So the other planets can also bear life or can be made life nurturing by infecting them with life.

Life can be found under variable set of environmental conditions on planet Earth. There are Microorganisms, which can live and grow in most extreme environmental conditions. They can be found living at the bottom of deep ocean floor, near hot springs, ocean floor volcanoes, on highest mountains and at north and south poles. This suggests that life finds a way, i.e. life can evolve to any planetary conditions and grow.

Life can grow and evolve on a planet like earth, but can it travel from one planet to other? It was found out that some bacteria and viruses can survive the extreme cold, radiation and vacuum of space environment. These unicellular organisms go to a dormant or hibernation stage and come out when favourable conditions come.

As we know number of meteorites and asteroids travel in an elliptical path around Sun. Many of them hit distant planets, satellites and worlds never seen and we have never been. Therefore, by planting life forms inside them, we can send the seed of life to distant Galaxies. On the alien planet, when these unicellular organisms find favourable conditions, they will grow and evolve. May be in distant future they will come and visit Earth.

Development of science and technology has enabled us to travel to other planets. But many planets we are finding are uninhabitable. We are searching for planets in our galaxy but there are millions of galaxies in the universe. So mankind can never reach all of them or examine the possibility of life forms on those planets. But if the distant planet is life sustaining we can plant the seed of life in there. To achieve this, instead of reaching near the planet we can use asteroids to accomplish the task. The main Asteroid Belt and Kuiper Belt are the major source of asteroids. Robotic Landers can be used to reach near the asteroids and inject selected microorganisms inside them.

These arbitrary travelling asteroids will go to most distant galaxies and plant the seeds of life. This way the existence of life will continue in the universe.

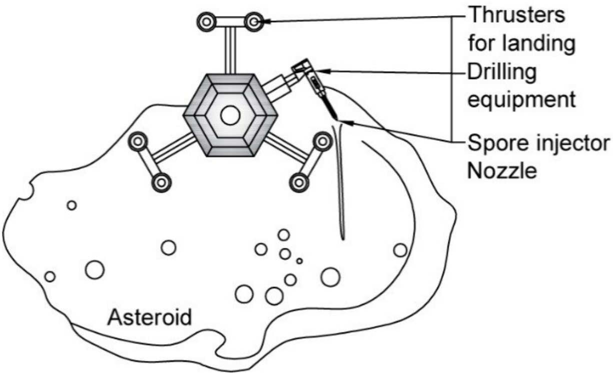


Figure-27.1, Robotic Lander, Planting seeds of life inside an Asteroid

Above shown is a Robotic Lander attached to an asteroid. After being attached to the asteroid, the robotic Lander will drill a hole to the depth of the asteroid and plant the spores of some specific microorganisms. These microorganisms are selected by their specific traits to survive in extreme environmental conditions. Some of them can be genetically modified to help them tolerate the space radiation and extreme planetary surface conditions. As the asteroid will travel to distant solar systems, it will crash in to some planet in distant future. By directing its path towards the target planet we can make a controlled impact. After the impact, dormant life forms inside the asteroid will come out of their carrier and be exposed to the new planetary environment. Finding favourable environmental conditions the microorganisms will grow and evolve on the alien planet. Some day we might meet out descendants as evolved and intelligent life forms.

Chapter-28
Mutation of Humans-Super Humans

For living on an alien planet we have to Terraform the planet or we can make the necessary mutation in human DNA to survive the variable set of planetary environment.

Humans are the most dominant species on the planet Earth. We are the result of million years of evolution and natural selection. Like humans every living organism on the planet has evolved from the single celled early life forms floating on the primordial oceans.

Every organism's life cycle follows a pattern of birth, growth, reproduction and death, which involve number of complex cellular activities. The life cycle and reproduction of every organism is controlled by it Chromosomes. Chromosomes contain the codes to carry out every cellular activity. It consists of DNA (Deoxyribose Nucleic Acid), RNA (Ribose Nucleic Acid) and Protein (Amino Acids). Organisms store information as DNA, release or carry information as RNA, and transform information into the Proteins that perform most of the functions of cells.

DNA is a double helical structure formed by bonding between the nucleotide bases. The bases come in four chemical forms known as adenine, cytosine, guanine, and thymine, which are simply abbreviated as A, C, G and T. The sequence of bases encodes the information in DNA.

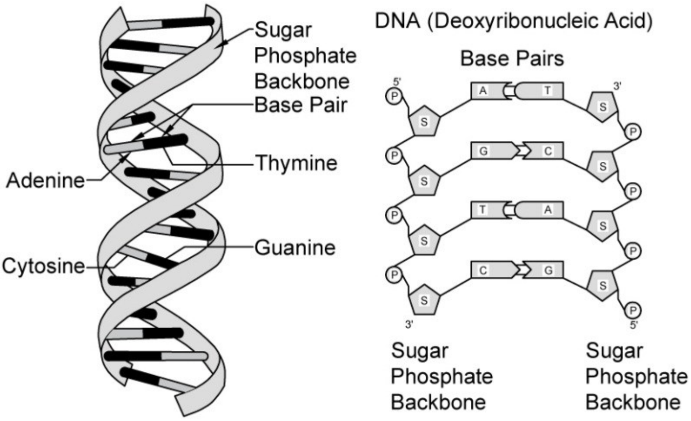


Figure-28.1, Structure of DNA Molecule

The shape and charge of the bases cause A to bond weakly to T, and C to bond weakly to G. The bases from one strand of a DNA helix are in a mirror image of the bases in the other strand, when there is an A in one strand there is a T in the other; when there is a C in one strand there is a G in the other. The sugar and phosphate components run up the outside, with the matched bases forming ladder like structure in the centre.

During Cell division, enzymes separate the two strands of the double helix, pulling apart the paired bases. Other enzymes start new DNA strands, using the base pairing rules to make a new mirror image of each of the original strands. Chromosomes multiply themselves in cell mitosis by DNA replication. Mistakes in this process can lead to Mutations.

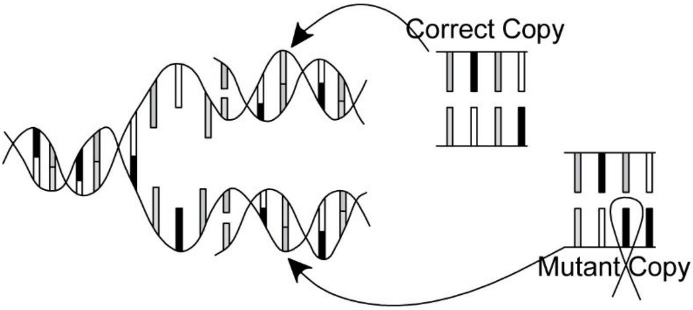


Figure-28.2, Genetic Mutation

Chromosomes are contained inside Nucleus of every living cell. In Prokaryote organisms DNA is organised into an arranged structure in the form of Nucleoid in every chromosome. Because there is no well-defined nucleus, so the chromosomes are simply attached to the cellular membrane. But in case of eukaryotes they are contained inside the nucleus. The DNA is arranged by chromatin proteins into a condensed structure, Chromosome. This helps the very long DNA strands to fit into Nucleus.

DNA (Deoxyribose Nucleic Acid) contains Genome that instructs the function and development of every living cell. Genome is the genetic material containing Genes and Noncoding DNA. Genes or Coding DNA is "transcribed" into a RNA which then produces proteins by the process known as "translation."

DNA replication is the process by which the organism undergoes cell division. But during the cell division i.e. mitosis or meiosis Genetic Material DNA or RNA may get affected by external catalyst to change their chemical and structural consistency known as genetic mutation.

Mutation is the permanent change in Nucleotide Sequence of Genome of an organism caused by radiation, chemical mutagens, error in replication process or from insertion and deletion of segment of DNA.

Mutation can produce visible change in organism characteristics causing evolution, development of immune system, cancer or abnormality etc. Some mutations may affect positively, helping the mutant organisms to withstand adverse environmental conditions on the planet by reproducing faster or being resistive to some kind of disease. By which it plays an important role in evolution and natural selection.

Evolution is slow and a long term process, while Mutation is spontaneous and accidental. But by genetic engineering we can reproduce positive mutation in lab. For a long time methods of genetic engineering has been developed and rectified for creating GMO (Genetically Modified Organisms). Many GMO are presently in use like Genetically Modified Insulin Producing Bacteria, Glow fish, Genetically Modified crops to fight drought has been commercialised in many countries.

Any living cell can be genetically modified by genetic engineering and if the cell is reproductive then the character will pass on to the next generation. There are two types of genes, Coding and Non-Coding. The Coding ones are responsible for the characteristics of the organism while the non-coding are the sequence of genes passed on by our ancestors and not used for RNA transcription. So by understanding the Genes in living cell we can point out the one ones responsible for particular behaviour of the organism. By the process of genetic engineering we can stimulate mutation in human embryonic stem cells to inherit certain new characteristics.

By mutation we can not only achieve better human beings, but we can adjust the body morphology and physiology to fit into new environmental condition of an alien planet. We can add genetic material from different organisms on our planet or recombine them to mutate human genetic code so that humans can adjust to Alien planets.

There are certain characteristics of other organisms which we can assemble inside our chromosomes to make us better humans.

1. Hibernation: Hibernation is the typical characteristic of a cold blooded animal also known as endotherms. It is a state of inactivity and metabolic depression. Hibernation is characterized by low body temperature, slow breathing and heart rate, and low metabolic rate. Hibernation has been observed in rodents, namely ground squirrels and reptiles but no primate or mammal was known to hibernate. Later it was found that the fat-tailed dwarf lemur of Madagascar hibernates in

tree holes for months. So hibernation can be stimulated by drastic variation in outer temperature in certain animals.

In future space travel we may have to journey light years for finding a habitable planet. Hibernation is characterized by low body temperature, slow breathing and heart rate, and low metabolic rate which can be helpful for long distance space travel. Even if we have a self-sustaining ecosystem inside our spaceship, hibernation can save us appreciable amount of energy and resources. Or for living on a deserted planet which environmental temperature varies between extreme limits hibernation can be our ally. We can go into hibernation at the advent of extreme environmental conditions or prior to space travel.

2. Gills and Piscean characters: Fishes and aquatic organisms have some specific characteristics. Like fishes have gills to absorb oxygen from water, fins to swim in water, oily skin to avoid water osmosis inside body tissues and swim bladder or air bladder for up and down movement inside water. By mutation achieving some or many of these characteristics by a new species of humans will be able to live inside giant water world of other solar systems.

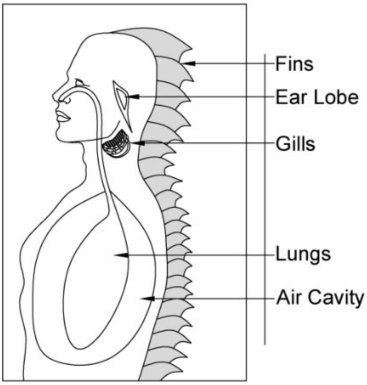


Figure-28.3, Genetic Mutation, Piscean Human

3. Increased brain size: Brain is the source of intelligence, reasoning and consciousness for complex organisms. Large animals such as whales and elephants have larger brains, but considering Encephalization quotient, which is a measure of relative brain size defined as the ratio between actual brain mass and predicted brain mass for an animal of a given size humans have the larger brain than dolphin and chimpanzee. The human brain is the same in structure as the brains of other mammals, but has a more developed cerebral cortex than any other. So if by mutation certain areas of human brain can be developed in size and complexity the next generation will be more intelligent and may be more adaptive to adverse environmental conditions.

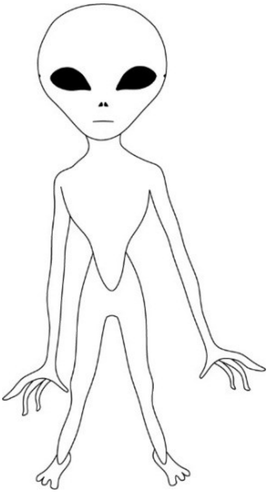


Figure-28.4, Genetic Engineered Human, Larger Brain size and highly efficient

4. Chlorophyll Inclusion: Photosynthesis, the process by which light energy from the sun is used to synthesize sugars from carbon dioxide and water, releasing oxygen as a waste product. Chlorophyll pigment inside the cell is responsible for this process. It allows plants to absorb energy from light and convert the energy into chemical energy. Molecular formula of the common two types of Chlorophylls are, Chlorophyll-a ($C_{55}H_{72}MgN_4O_5$) and Chlorophyll-b ($C_{55}H_{70}MgN_4O_6$). Chlorophyll has structure of (2-formyl)-chlorophyll. At the centre of the chlorine ring is a magnesium ion. This was discovered in 1906, and it was the first time that magnesium ion had been detected in a living tissue.

Early unicellular organisms with photosynthesis ability like green and purple sulphur and green and purple nonsulfur bacteria were anoxygenic, using hydrogen and sulphur molecules as electron donors.

Within early plants some synthesised Chlorophyll pigments for photosynthesis. In more evolved organisms the Chlorophyll pigments are organised inside cell organelle, Chloroplast. Chloroplast is the organelle inside the cell which has high concentration of Chlorophyll pigment and primary place of photo synthesis. Chloroplasts have their own DNA and ribosome. Therefore, chloroplasts are considered photosynthetic bacteria that has adapted to live inside plant cells.

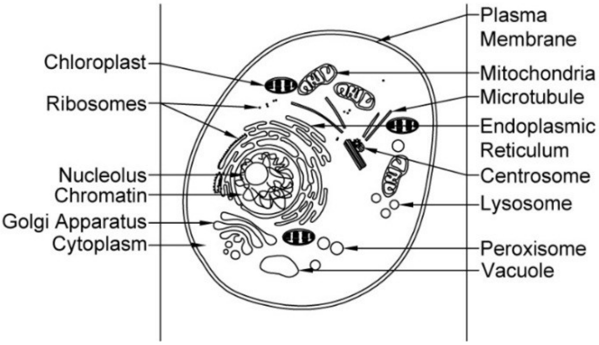


Figure-28.5, Mutated Human Cell containing Chloroplast

Symbiosis of early organisms may explain the origin of Chloroplasts. Chloroplasts have many similarities with photosynthetic bacteria, including a circular chromosome, prokaryotic-type ribosome, and similar proteins in the photosynthetic reaction centre. The endosymbiotic theory suggests that photosynthetic bacteria were incorporated to cell by endocytosis of early eukaryotic cells to form the first plant cells.

Some animals show symbiotic relation with photosynthetic algae. Some species of molluscs assimilate the algae in form of food and store the chloroplasts inside their body. This allows them to survive for a long time depending only on photosynthesis. In this case some genes from the algae cell are transferred to animal's nucleus for required protein synthesis of chloroplasts.

The human cells can be genetically engineered to hold chloroplasts as an organelle. As chloroplasts require certain kind of protein we may have to modify humane DNA for the required protein synthesis. If this process works humans will be able to produce their own oxygen and food just by drinking mineralised water and standing in sunlight. This will help us to survive in future extreme environmental conditions and adjust to atmospheric extremities. If we can achieve all above conditions by our technology we surely can mutate human genome to breath in low oxygen atmosphere, high carbon dioxide rich atmosphere or in a toxic environment.

It will take generations for natural evolution or even we will die before adapting to alien environment. But with the help of genetic engineering we can shorten the time period to two or three generations. So that a new race of humans will evolve who can live on a different planet.

Chapter-29
Biological, Chemical and Nuclear Interference

The aim Terraforming a planet is to make it habitable for humans. For this we may need one or many of our tools to change the planetary atmosphere, hydrosphere and environment. If the planet has no life forms on it, we have to plant seeds of life to slowly evolve planetary environment. If the planet is inhospitable for life forms we may have to use chemical and nuclear interference to make it life sustaining.

We know that biosphere of a planet plays an important role in planetary atmospheric evolution. As discussed previously earths Oxygen rich atmosphere and habitable environment is the result of long term interaction between biosphere, hydrosphere and atmosphere. From this it is concluded, that the environmental conditions of a planet can be changed by the activity of organisms. So by planting seeds of life we can slowly change the inhospitable conditions on a planet as described previously (Chapter-26).

Since the discovery of nuclear fission a lot of research has been carried out in the field of nuclear energy. Presently we are trying to control nuclear fusion to generate unlimited amount of energy.

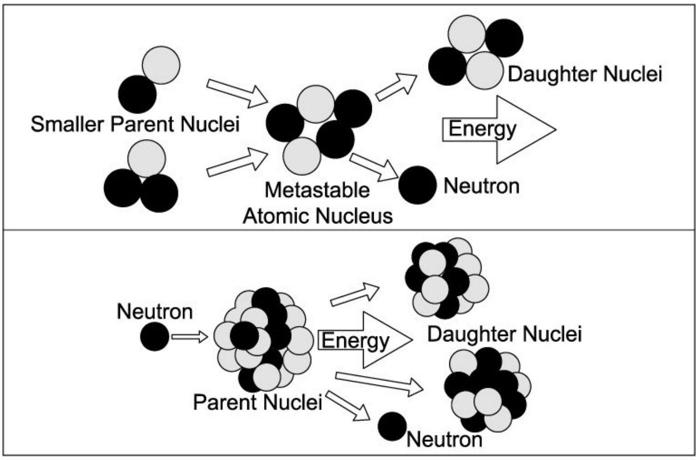


Figure-29.1, Fission and Fusion Reaction

Nuclear fission is the process in which a heavy parent nucleus breaks into number of two or more daughter nuclei producing neutrons and protons and releases a huge amount of energy. While nuclear fusion is the process in which two smaller nuclei combines to form a heavy nuclei producing neutrons and energy. This is the process by which stars produce their infinite amount of energy. The process of fusion of fission has a characteristics property of generating unlimited amount of energy.

In some planets the interior of the planet may be in hot molten state, while the surface temperature of the planet is too low to establish human habitation. On such planets sudden release of energy by fission or fusion may cause notable change in atmospheric conditions. Nuclear energy can change the climate of the planet sudden release of energy.

If the planet is far from the central star, it will receive lesser sunlight and surface temperature will be much below the normal. By the process of fusion and fission we can generate continuous heat and energy to establish settlement on a small part of these frozen planets. Controlled fusion or fission process will help us by recycling the cold air of the planet, to make it breathable and tolerable for humans. For this nuclear power plants are to set up on the planet for recycling the air. In a time period the surface temperature will be tolerable for human settlement.

Chemical interference is the process of changing the atmospheric chemistry of a planet is to make the atmosphere on the planet nontoxic and breathable. As we have discussed previously atmospheric dissociation and atmospheric precipitation (Chapter-22 and 23) can be used for transforming the planetary atmosphere.

So by the cumulative effect of biological, nuclear and chemical interference we can transform an uninhabitable planet to an earth like habitable environment.

Chapter-30

Organic Space Ship

Human body is the host for millions of parasites which live inside their intestine, blood vessel and internal organs. Not only humans all the Multicellular organisms show symbiotic relationship with microorganisms. Some organisms show symbiosis with other Multicellular organisms.

For some Liquid and Gaseous planets where the entire planet is an ocean of chemicals or is a hodgepodge of organic or inorganic compounds we can live with symbiotic relationship with organisms living on the planet. Else we can use genetically engineered organisms to live on the planet.

Photosynthesis is the major process which provides significant storage and food for all living organisms on the planet earth. It is suggested that photosynthesis started after the origin of primary chemoautotroph. Many prokaryote bacteria shows photosynthetic characteristic. Some evidences indicate eukaryotic photosynthesis started with Endosymbiosis of Cyanobacteria like organisms by cell, which ultimately became chloroplasts.

So symbiosis in organisms is not new we can find many other evidences of symbiosis in much developed organisms.

Symbiosis is an interaction between two or more different biological species living associated to each other. The mutual relation of symbiosis is classified into three categories Mutualistic, Commensalistic, and Parasitic. In Mutualism both the species involved are benefited. Example-Coral reefs, mutualisms between coral organisms and various algae living on them. Another is the symbiotic relationship between clownfish and sea anemone. Clownfish feeds on small invertebrates which harm the sea anemone and the faecal matter of clownfish provide nutrients to sea anemone. In the other hand clownfish is protected from predators by anemone's stinging cells to which it is resistant.

Commensalism is the relationship between two living organisms where one benefits and the other is not significantly harmed or helped. Example-Examples Hermit Crabs using Gastropod shells to protect their body.

Parasitism is the relationship in which one organism is benefited known as parasite while the other one is harmed known as host. Example-tick feeds on organism’s blood.

The same way like a parasite lives inside a host, humans can live inside organisms of alien planet to protect themselves from unfavourable environmental conditions. But for the same few assumptions are to be made.

1. The organism should be large enough to support a sizable human colony.
2. The organism should be a plant in alien planet which is attached to substratum i.e. non locomotive and Photoautotroph.
3. The plant should be long living so that humans do not have to change their domicile frequently i.e. biologically immortal.

It would be better if the host has a long life expectancy. If the organisms cells does not die or age with time the organisms is called biologically immortal. It is represented by mortality rate. Mortality rate is a measure of the number of deaths in a population, scaled to the size of that population, in unit time. It is typically expressed in units of deaths per 1000 individuals per year.

Immortality is the characteristic of living cells that are not subject to the Hayflick limit, the point at which cells can no longer divide due to DNA damage or shortened telomeres. A telomere is a region of repetitive DNA sequences at the end of a chromosome. It protects the end of the chromosome from deterioration. Biologically immortal organisms are still susceptible to causes of death besides aging, including diseases, accidents, and predations.

Tardigrades, also known as water bears, are microscopic, water-dwelling and segmented animals. Tardigrades are able to survive in harsh circumstances that would kill almost any other animal. Some can survive temperatures of close to absolute zero (−273 °C) temperatures as high as (151 °C), 1,000 times more radiation than other organisms, and almost ten days without water. Tardigrades are one of the few groups of species who has the ability to suspend their metabolism and going into a state of Cryptobiosis.

Scientists have recently discovered the world’s first known immortal animal. A jellyfish species named Turritopsisnutricula. The jellyfish’s secret to genetic immortality lies in it reverting back to a younger stage in its life. After attaining maturity it enters an earlier polyp stage after it mates, and by doing so, completely restarts its life cycle.

There are organisms which are huge enough to support a small colony of human’s inside them. If we could combine some of the characteristics of above said organisms the GMO (Genetically Modified Organism) will be our life support vehicle. The genetically mutated organism will be large enough, photosynthetic and immortal.

Such an organism will provide humans with food, shelter and protection from outer environment.

Under favourable circumstances at a colony level, Bacteria are said to be biologically immortal. Hydras are fresh-water animals, which do not experience aging process and survive for millions of years.

Depending on the internal body structure of multicellular organisms Hydra is the most suitable candidate for Organic Space Ship Therefore a genetically modified large sized hydra, with photosynthetic ability, immortal and immune to alien planets environmental conditions can support a small sized human colony.

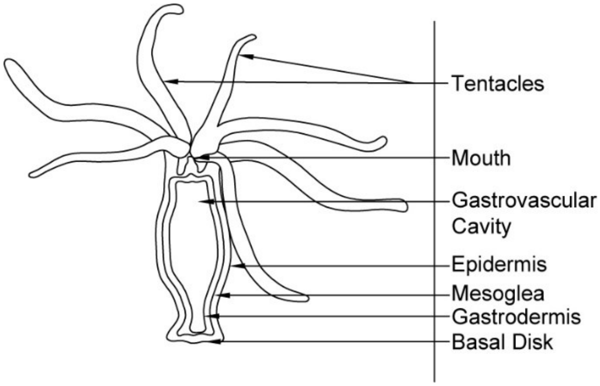


Figure-30.1, Cross Section View of Hydra

Above shown is a cross section view of Hydras body cavity. It consists of central body cavity, tentacles, mouth and a basal disk. The gastro vascular cavity inside the body of the organisms can be used for habitation.

Below is picture showing the possible Genetically Modified Hydra in alien planet. The mutated Hydra is large enough to support a small human colony (large body cavity), immortal (does not have a natural death), sessile (attached to a substratum and does not move) and photosynthetic (cell contains Chloroplast for producing its own food from Sunlight, Water and Carbon dioxide). Humans can depend on such Genetically Modified Hydra for habitation and food.

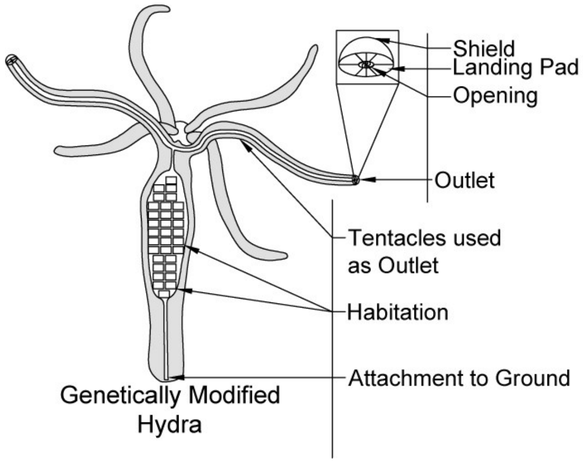
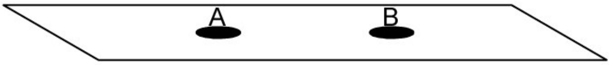


Figure-30.1, Human Habitation on Alien Planet, Genetically Modified Hydra

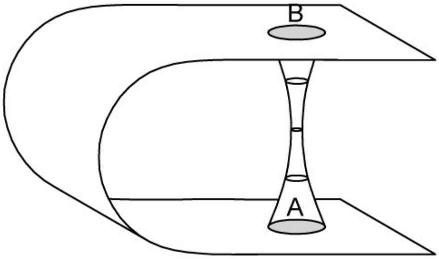
Chapter-31

Worm Hole and Black Holes

Worm hole, also known as Einstein–Rosen Bridge is a shortcut or path between two points in space and time. If the distance between two points A and B is X on a paper, by folding the paper we bring those two points close and now the distance between them is Y. Then path Y is a worm hole. So worm hole for a two dimensional paper is a tunnel passing from A to B, but for space and time it will be a sphere.



2 Points on a Two dimensional Space



The shortest path traversed by folding the two dimensional space is a Worm Hole expressed on the 2D space as Circle

Figure-31.1, Depiction of a Worm Hole

In general relativity it is suggested Lorentzian traversable wormholes would allow us to travel in both directions from one part of the universe to another part of that same universe very quickly. So we can travel between any two places with the help of worm hole prior to arrival of any disaster. For an example, before our sun turns into a red giant or a moon sized metallic asteroid hits the Earth, we can transport all the humans to another Terraformable planet and save the human civilization.

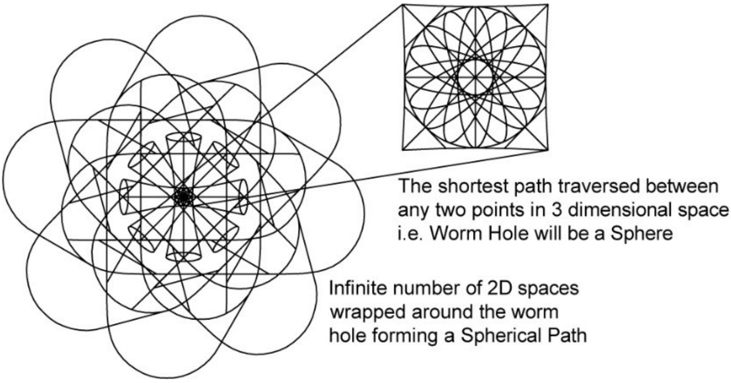

The shortest path traversed between
any two points in 3 dimensional space
i.e. Worm Hole will be a Sphere
Infinite number of 2D spaces
wrapped around the worm
hole forming a Spherical Path

Figure-31.2, Spherical Wormhole in Space

We have many telescopes on earth and in orbit around our planet looking for other distant Solar systems and planets. We have found many and will discover more number of them in future. Some of them may be Terraformable or habitable. But these newly discovered planets are light years away.

Until now, we know that it is impossible to travel faster than light. But with the help of traversable worm holes we can travel to any part of universe within human life time.

The Multiverse is the hypothetical infinite set of possible universes that together comprise everything that exists: the eternity of space, time, matter, and energy as well as the physical laws and constants that describe them. The various universes within the Multiverse are sometimes called parallel universes. Some scientists suggest a particle travelling through a worm hole does not return to its primary universe, but travels to a parallel universe. So if in future we find no other place to live we can travel through a worm hole and travel to a different parallel universe.

Black Holes are celestial objects of high stellar mass, from which gravity prevents anything, including light, from escaping. They are formed when very massive stars collapse at the end of their life cycle. It grows by absorbing mass and merging with other Black Holes. Gradually a Black Hole becomes a super massive Black Hole. Scientists expect every spiral galaxy has super massive Black Holes at its centre.

Black Hole is noticed by its drag on the neighbouring stars and planets and the ring of matter surrounding its boundary. Due to frame dragging, the space around the Black Holes rotates along with it. This elliptical region from where matter and light escapes the Black Holes is known as Ergo Sphere. The boundary between Ergo Sphere and the surrounding is known as Ergo Surface. Below Ergo Sphere is the photon sphere, it is the spherical boundary where photons entering the region are trapped in a circular orbit forever.

Photon Sphere separates Event horizon and the Ergo Sphere. Event horizon is the region around the Black Holes from where no object can escape not even light. And inside the event horizon at the centre of the Black Holes lays the singularity, a region where the space-time curvature becomes infinite.

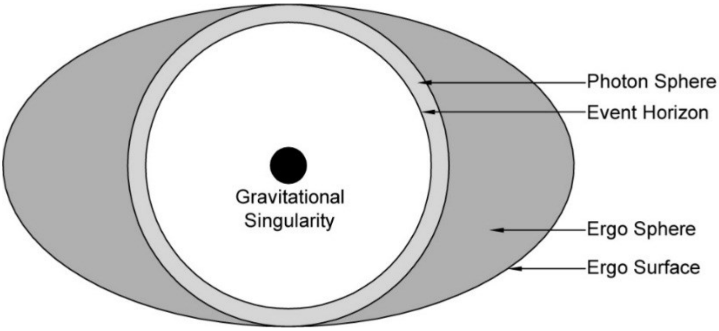


Figure-31.3, Structure of a Black Hole

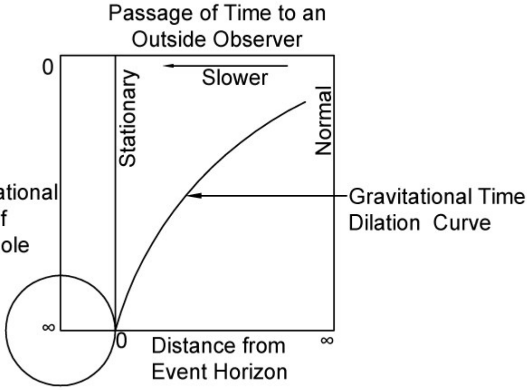
To travel to planets far as light years we shall require huge amount of energy. For propulsion in space we use various fuels, from burning them we generate energy and thrust. But every time we do this some amount of energy is lost during the conversion, as none of our engines are 100 percent efficient. So we need an engine which can convert matter to energy with 100 percent efficiency.

According to current calculations no matter or information entering the Black Holes is lost. Black Holes radiate them back in form of thermal radiation. By radiating energy Black Holes shrink and evaporate. This radiation of Black Holes is known as Hawkins radiation, as it was first suggested by Dr. Stephen Hawkins. According to him smaller the Black Holes faster it evaporates. The Black Holes emits all the absorbed matter in form of pure energy during its annihilation. As Black Holes convert matter to energy with 100 percent efficiency, we can use Black Holes as our energy producing engines.

So if we can condense matter at one point we can create miniature Black Holes. Anything we throw at the Black Holes will be radiated as Hawkins radiation. This energy can be contained using suitable enclosure. These Black Holes can be used to convert matter to energy which will give 100 percent efficiency or a perpetual engine.

Due to their enormous mass, super massive Black Holes can be used as time machine for future humans. Back holes are immensely massive, which gives them a power to curve the fabric of space around them. Just like the time dilation on earth, same can be expected close to Black Holes. Because of Gravitational Time Dilation, somebody close to a massive object will experience time slower than a man far away. Gravity slows down the time. Time will run faster as we move away from the Black Hole.

As Terraforming sometimes requires a very long time span, depending on the planetary geological conditions it may be difficult for humans to survive that long. Humans may have to wait too long in space without any source of energy or food to live. In such cases a space ship designed to fly close to the Black Holes will be advantageous.


Passage of Time to an Outside Observer
0
Slower
Stationary
Normal
Gravitational Filed of Blackhole
Gravitational Time Dilation Curve
∞
0
Distance from Event Horizon
∞

As we move closer to the Event Horizon Time slows down and finally stops to an outside observer as a result of Gravitational time Dilation

Figure-31.4, Curve showing Time Dilation near Black Hole due to effect of Gravity

Let, humans have travelled to a distant galaxy, found a Terraformable planet and decided to settle on the planet for the time being. If the planet is habitable we can settle on the planet easily. But if the planet's surface and geological conditions are very different from earths, we have to Terraform the planet. Depending on the planetary conditions it may take thousand years to completely Terraform the planet. If we do not have the amount of fuel and resources for that long to survive and continue the Terraforming process, until the Terraforming finishes our civilization may have ended. Moreover anything can happen in that long time, leading to an end of human civilization.

In such case we have to travel to the nearest Black Hole. Closer we get to the Black Hole time slows down, i.e. one year spent around the Black Holes will be equal to 100 years on the Terraformable planet. We have to design a spaceship with ability to revolve close to it. As we revolve around the Black Hole time will be spent much faster.

Programming all the processes of Terraforming on the planet we may journey to the Black Hole. We can spend few generations on the space ship around it and return to the Terraformed planet.

Chapter-32
Teleportation and Antimatter

For Terraforming we have to travel to distant solar systems and transport huge machines from one planet to other, this is where we shall require the technology of Teleportation.

We have all heard of wrap drive. It is the term used for travelling between two points in space faster than light.

Worm hole is one way of travelling between two distance places in short time, Teleportation is another method for travelling faster. For many years theories are put forward for teleportation. It has been associated with many science fiction and stories. Even scientists had tried to understand and stimulate teleportation.

But there is one problem with all these theories. All these theories and fictions suggest converting the object into energy and relay it to a receiving station. At the receiving station a receiver will collect the beamed energy and condense it to form the primary object. Collecting all the information at the receiving station without any loss of data is very difficult, also recreating any object from pure energy. As we know photon has both particle and wave characteristic. So, multiple copies of the primary object can be generated at the receiving station, while the original object will be destroyed during the conversion process. Also there will be some loss of data during the transmission, which will create number of deformed replicas.

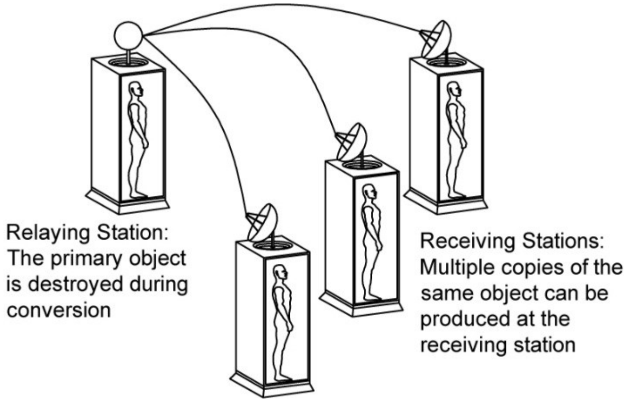


Figure-32.1, Multiple copies of the Primary Object generated due to Teleportation

This method of Teleportation may be used for non-living objects, but not for humans. So to Teleport humans we have to find another way.

For which a theory is suggested. Two men are standing near a swimming pool. Now both of them have to travel to other side of the pool. One man may walk by the side of the pool, while the other man will swim to the other side of the pool. We can say the man walking by the side of the pool travels in one dimension, while the one swims inside the pool travels in two different dimensions. The man traveling form one medium to other, then back, takes shorter time period compared to other.

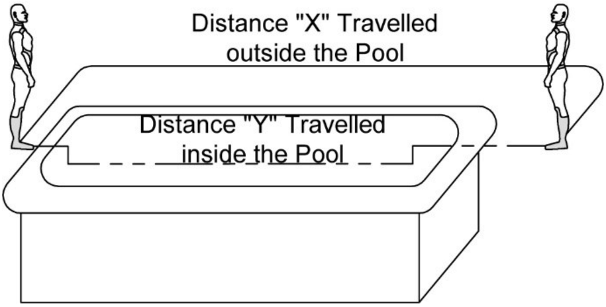

Distance "X" Travelled outside the Pool
Distance "Y" Travelled inside the Pool

Figure-32.2, Assuming Interdimensional Teleportation

We consider the man swimming inside the pool as travelling in two different dimensions. One, when he is outside the water, then he dips at one point and comes out at other point. The same way if we can travel to another dimension and come back we can teleport matter and humans faster than ever. The concept suggests an inter-dimension travelling spaceship, which will travel from our universe to another dimension where distance between the targeted points is lesser than ours. When it comes back at the other end, it has travelled desired distance in comparatively short time in our universe.

As shown above, let the space ship will start its journey from A and have to travel to B. Distance between A-B is, X in our universe. But in another universe distance A-B is very small let Y i.e. $Y<<X$. Now, if the Spaceship travels A to B in our universe, it will take the usual time period. But if the Spaceship starts its journey from A in our universe and travels to another dimension, completes the journey A to B. Then the ship comes out at B it will take short time period compared to actual travelling time. In this way using an inter-dimensional space ship we can transport humans from one solar system to another in very short time.

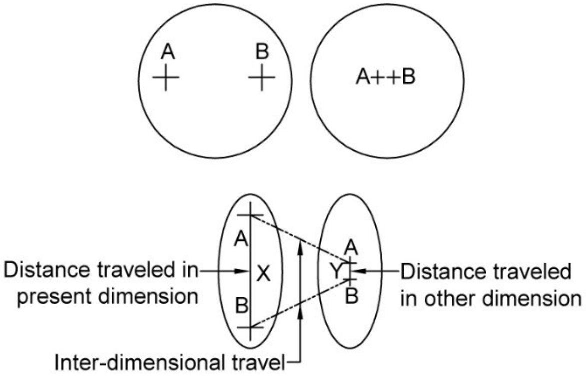

A
B
A++B
A
X
B
A
Y
B
Distance traveled in present dimension
Distance traveled in other dimension
Inter-dimensional travel

Figure-32.3, Concept of Teleportation

Antimatter or dark energy is the primitive matter of universe. It is said that matter and antimatter originate from every point in space and destroy each other. Collision of matter and anti-matter particles generate huge amount of energy, which is much more compared to chemical or nuclear energy. This can solve our future thirst of energy. In future it will be possible to colloid matter and antimatter particles to get pure energy. These particle colliders will provide enough energy for our visionary projects.

Chapter-33
Gravity Defying Spaceships

Each time we travel to space we have to spend huge amount of energy to overcome the gravitational field of Earth. If we could avoid the gravitational field of Earth we could travel to space much cheaper and easier way. Whenever we send a space probe or satellite to another planet or moon the space probe have to overcome earth's surface gravity and then orbit around Earth to build momentum for the journey.

Gravity is the characteristic of mass. So every object with mass attracts other with the force of gravity. Till now scientists have found every form of energy have an attractive and repulsive nature. But gravity is always attractive it never repels. So to solve the problem antigravity, graviton and many hypothesis are put forward.

Gravity is both our enemy and friend. It is the Omnipresent and Omnipotent energy which creates us and nurtures us. It is the weakest of 4 fundamental interactions.

Fundamental Interaction	Strength	Range	Carrier Particle
Strong Nuclear	1	10^{-15}	Gluon
Electromagnetic	1/137	Infinite	Photon
Weak Nuclear	10^{-6}	10^{-18}	W and Z bosons
Gravitational	$6*10^{-39}$	Infinite	Graviton

Table-33.1, Fundamental Interactions

Every object with mass attracts the other. So if two objects attract the third one, the targeted object will move towards the object with higher mass. Or the object will move towards the one which creates more depression on space and time fabric i.e. irrespective of the mass which has higher surface gravity and close to the target object. In case the stationary objects are of same mass, the object will move towards the object with strong gravitational field.

Gravitational field experienced by a smaller mass at height h from the surface of Earth object is given by:

$$g=GM/(R+h)^2$$

Where G is the gravitational constant

M is the mass of Earth,

R is the Radius of Earth

h is the height form surface of Earth

and g is acceleration due to gravity

So with increasing height value of g experienced will decrease rapidly. Gravity is always attractive unlike other fundamental forces. So we can avoid the gravitational pull of one object by falling into another strong gravitational field. But if each time we miss to fall into any of them that will give us the desired imitation of weightlessness or we can cheat gravity.

Between two Massive objects in space there is a point, where the gravitational pull on the targeted object by both the objects neutralise each other. These points are known as the Lagrangian points. There are five Lagrangian points in space around two larger objects, where a smaller object can maintain a stable orbital configuration due to gravity.

The idea of Lagrangian points can be applied to overcome the force of gravity. There is a point between two stationary objects in space, where a moving object can maintain a stable orbit, i.e. the object is pulled by both the stationary objects with equal gravitational attraction. So by increasing the gravitational field strength of one of the stationary objects, we can direct the path of the target.

Force of gravity, with which every object attracts other with mass:

$F=Gm_1m_2/r^2$

Where F= Force of gravity

G=Gravitational Constant

m_1 & m_2 mass of two arbitrary objects

r is the distance between two objects

In case, mass of one object is negligible to another i.e. smaller object is of unit mass.

$F=GM/R^2$

Where R is the radius of bigger object

So for considering the force between an earth size object with another smaller mass, we consider surface gravity or gravitational acceleration as the measurement parameter.

Where surface gravity is g

$g=GM/R^2$

So surface gravity g is:

$\Rightarrow g \propto M$

$\Rightarrow g \propto 1/R^2$

So mass being constant varying the radius will alter the value of surface gravity. If the radius of an object increases mass being constant surface gravity will decrease. I.e. the average density of the object is changing each time we change any of the parameters.

From above equation we can say:

$g=GM/R^2$

$\Rightarrow g=GVM/VR^2$

Where V is the volume of a spherical object

We know $V=4/3\ \pi\ R^3$

$\Rightarrow g=G4\ \pi\ R^3M/3VR^2$

$\Rightarrow g= G\ \pi\ R\rho 4/3$ (M/V is density of the object denoted as ρ)

So from above, we find density of the object being constant surface gravity of the object varies with size or radius.

Mass being constant, $g \propto R$

So value of surface gravity depends on density of the object i.e. despite having same mass two objects can generate different gravitational field, close to the surface. An object with lower mass can generate higher surface gravity at a highly condensed state. Which concludes a small object can also generate enough surface gravity like Earth, mass being the same.

From above we can draw the curvature of space around two objects of the same mass and variable size (radius) as given below. It is observed, that as we compress the object with increasing density and decreasing radius, the gravitational field lines become crowded and field intensity increases close to the surface of the object.

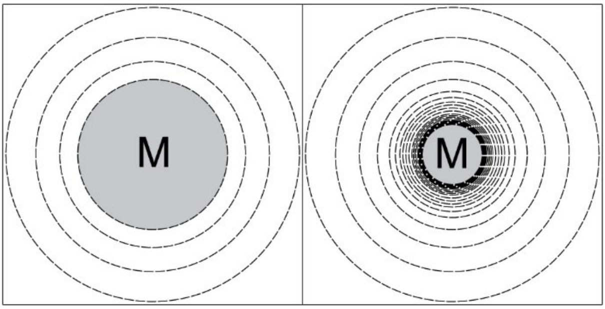


Figure-33.1, Gravitational Field of two objects with same mass and variable size

If we can compress an object to effective density it can generate enormous surface gravity. Of course an object can be compressed only to a limit. Every atom consists of a nucleus and electron cloud around them. The nucleus consists of nucleons protons and neutrons. These nucleons are held together by nuclear strong force which is a short range but very strong force.

Every proton repels the other with a less strong force known as electrostatic force. Though electromagnetic force has infinite rage it is weaker than strong nuclear force. The strong nuclear force is created between nucleons by the exchange of particles called mesons. In order to bring protons closer we have to cross the barriers of electromagnetic force so that the particles come in range of strong nuclear force.

Because electromagnetic force is the reason of repulsion among protons the same can be overcome by applying stronger field.

To calculate the surface gravity of an object consisting only of protons we have to go to the beginning.

$g= G \pi R\rho 4/3$

Considering the object consist of entirely protons. The hypothetical mass of protons can said Protoneum. The protons inside Protoneum are hold close by strong electromagnetic field to assume a spherical shape contained inside a container. Let mass of the Protoneum be 100kg and surface gravity is same as earths 9.8 m/s^2 we have to calculate the effective radius.

Value of surface gravity g is given by:

$g=GM/R^2$

So the radius of the Protoneum Sphere will be:

$\Rightarrow R=\sqrt{} GM/g$

$\Rightarrow R=\sqrt{}6.67384X10^{-11}m^3kg^{-1}s^{-2}X100kg/9.8m/s^2$

$\Rightarrow R=\sqrt{}0.681004081632653 1X10^{-9}m^2$

$\Rightarrow R=\sqrt{}6.81004081632653 1X10^{-10}m^2$

$\Rightarrow R=2.609605490553415\ X10^{-5}m$

Now we have the radius of the Protoneum sphere which is 2.61 $X10^{-5}$m and the mass is 100kg. Hypothetically the object can generate enough surface gravity equal to Earth.

Proton has a half-life period of 10^{36} years while Neutrons has a half-life period of 612 seconds. So for the purpose of making condensed matter, it would be the ideal member. The range of Strong Nuclear force is 10^{-15} i.e. one Fermi. So the protons contained inside the containment should not come under the range of strong nuclear force. If we consider the particles are regularly distributed inside the container, we have to calculate the minimum distance between two protons.

Mass of one proton is $1.672621777X10^{-27}$ kg, radius of proton $0.8775X10^{-15}$m, so in 100kg the number of protons will be:

$n=100/1.672621777X10^{-27}=0.5978637930887109X10^{29}\approx 6X10^{28}$

So in 100kg there will be $6X10^{28}$ protons. To find if this arrangement of protons inside a sphere of represented radius is feasible, we have to calculate the space occupied by protons.

Volume of all the protons inside the spheres is:

$Vp=4\ \pi\ r^3\ X\ n/3$

$\Rightarrow Vp=4\ \pi\ r^3\ X\ 6X10^{28}/3$

$\Rightarrow Vp=4\ \pi\ r^3\ X\ 6X10^{28}/3$

$\Rightarrow Vp=4\ X22X\ (0.8775X10^{-15})^3\ X\ 6X10^{28}/3X7$

$\Rightarrow Vp=25.14X\ (0.8775X10^{-15})^3\ X\ 10^{28}$

$\Rightarrow Vp=25.14X\ (0.8775)^3\ X\ 10^{-17}$

$\Rightarrow Vp=16.9866073771875\ X\ 10^{-17}$

Where Vp is the cumulative volume of protons, Vs is the volume of containment sphere.

A closely packed n number of spheres inside a sphere of radius 2.61 $X10^{-5}$m will acquire volume percentage of Vp/VsX100 which should always be less than 70% of the volume of the sphere to make the arrangement feasible.

Where Vs will be:

$Vs=4\ \pi\ r^3\ /3$

$\Rightarrow Vs=4\ X22X\ (2.61\ X10^{-5}m)^3\ /3X7$

$\Rightarrow Vs=4\ X22X\ (2.61)^3\ X10^{-15}/3X7$

$\Rightarrow Vs=74.5\ X10^{-15}$

So Volume percentage will be:

$Vp/VsX100 =16.9866073771875\ X\ 10^{-17}/74.5\ X10^{-15}X100$

$\Rightarrow Vp/VsX100 =0.23\%$

So the resulting mass will occupy 0.23% volume, which is feasible as it is smaller than the threshold volume.

From above it is deduced that Protoneum can be created by containing a mass of protons with strong electromagnetic field. By controlling the electromagnetic field intensity, we can vary the surface gravity of the Protoneum Core and drive it in any direction. As the same is infinitesimally close to the centre of gravity of the spaceship, it will drag the spaceship with it. Below shown is s model of Gravity Defying Spaceship.

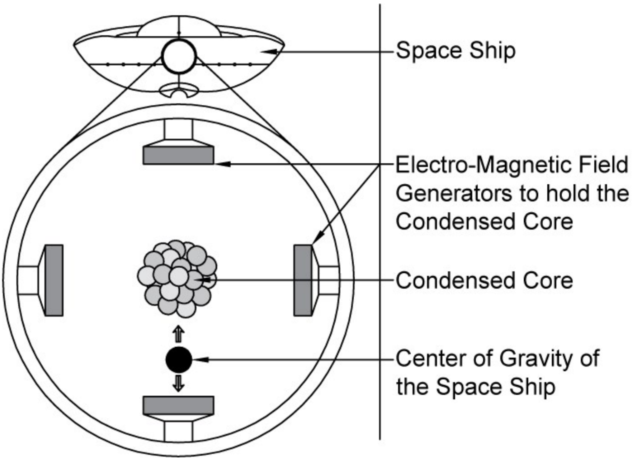

Space Ship
Electro-Magnetic Field Generators to hold the Condensed Core
Condensed Core
Center of Gravity of the Space Ship

Figure-33.2, Model of a Gravity Defying Spaceship

Now if this compacted mass placed close to the centre of gravity of the space ship, it will attract the spaceship towards it. But on the other hand the spaceship is being accelerated towards the centre of the planet. When both the values of gravitational acceleration equalises the object will stay in neutral gravity point. The neutral point is the point between the Earth and another massive object, where the gravitational forces of the object exactly equals the gravitational forces of the Earth. Since they are pulling in opposite directions, at the neutral point an object with zero velocity will attain a stable orbit without falling to Earth or other side.

If we compress the object more, the value of surface gravity will increase with increasing protons per unit volume. When the surface gravity of the core exceeds the gravity of Earth, the space ship will be dragged away from earth. But in this case both the Protoneum core and the space ship will act as one system, and will continue to fall towards the Earth. As we move the Protoneum in any direction using electromagnetic field the space ship will be dragged in that direction due to shifting of the centre of mass of the object. In this case the acceleration of Protoneum must be in opposite direction and greater than the acceleration due to gravity of earth. In this way we can navigate in space and on earth without burning Hydrogen, fossil fuel or any propulsion system.

Part-5: Conclusion

Chapter-35
Rules and Considerations

Terraforming requires abundant supply of energy and materials for the planetary scale transformation. Available resources on the planet can save us the toil of transporting necessary components from earth. Prior to Terraforming a planet, we have to check the availability of resources on and in the neighborhood of the planet to accomplish the terraforming process.

In future, Terraforming can save human civilization from annihilation. Not only that it compels us to explore and understand worlds beyond earth, it helps in expanding our knowledge about the universe. Among many reasons Natural Disasters, Asteroid Impact, drastic Geological or Environmental changes, world wide spread Epidemic that could end the era of humans. It will be wise to leave Earth and settle on another planet for the need of time.

In such cases Terraforming will be the last hope for humans if ever we have to leave this planet for any uncertain reasons. But before Terraforming we shall have to consider our priorities for destroying natural environment and the habitat of an alien planet and reshaping its environment for our requirements. Below are some considerations and rules needed to be followed before Terraforming any Planet:

1. Detail information should be collected about the target planet (Terraformable Planet) i.e. Geological, Atmospheric and Environmental, and analysed for possibility of successful Terraforming.
2. Samples should be taken from different parts of the planet and examined carefully for existence of any life forms. If no life forms are found, the planet can be Terraformed.
3. During collection of information about the planetary environment no harm should be imposed on existing population.
4. If we find any sign of life on the planet, it should be abandoned without interfering the organism’s natural course of evolution.
5. If we have no other option and the life forms are nonvirulent we can build habitable domes (Parraterraforming) on the planet else Parasitic Terraforming methods should be followed for our habitation outside a planet away from the hostile environment.
6. If we settle on the planet, Alien life forms should not be harmed for human settlement until required otherwise.

Chapter-36

Classification of Alien Civilizations

As we explore more about our universe we shall find millions of Galaxies, billions of stars with trillions of planets and many habitable worlds with life supporting components. On many planets we may encounter alien life forms which may be similar to ours or vary in physical and chemical composition. Though the chemistry of life forms on the planet does matter, still prior consideration of Terraforming the planet we have to understand the evolutionary stage of organisms on the planet and possible intelligent species. It is rather unethical to interfere in natures work.

Among thousands of habitable planets in the universe, some certainly contain life forms. Examining every planet for the same is not possible. Origin of life on a planet depend on variable parameters like existence of liquid water on the planet, distance of the planet form the central star, surface physical conditions (pressure, temperature), size of the planet etc..

Among the planets where life exists, in a very few, life has evolved to higher forms i.e. intelligent organisms. To know the number of intelligent civilizations in the universe Dr. Frank Drake suggested a solution. The Drake equation gives an idea of the number of intelligent communicable alien civilizations in our galaxy.

The equation was produced by Frank Drake in year 1961 at the world's first search for extraterrestrial intelligence (SETI) meeting, in Green Bank, West Virginia. The Drake equation:

$N=R \text{ X } f_s \text{ X } f_p \text{ X } n_e \text{ X } f_l \text{ X } f_i \text{ X } f_c \text{ X } L$

Where

N=Number of intelligent civilizations in our galaxy with which radio-communication might be possible

R=Average rate of star formation in our galaxy

f_p=Fraction of those stars that have planetary systems

n_e=Number of planets around these stars within the Habitable Zone or Ecoshell

f_l=Fraction of planets where actually life develops

f_i=Fraction of planets where living species evolve to intelligent life forms

f_c=fraction of intelligent species with advanced technology and can be communicated

L=life time or longevity of an advanced civilization

The equation was not intended to quantify the number of intelligent alien civilizations. It was put forward to arouse awareness and interest among the people for SETI (Search for Extraterrestrial Intelligence).

We can't possibly quantify the number of intelligent alien civilizations. But we can consider the variables affecting existence and identification of alien life forms on a distant planet.

For the same we consider two kinds of parameters: 1-Constants (which remain constant for a longer time period, symbol C), 2-Variables (which change within a short time period, symbol V).

So the numbers of alien life forms in the universe at a certain time period will depend on the following parameters:

1. Number of Galaxies in the Universe (C)
2. Number of Stars in those Galaxies with their own solar system (C)
3. Size of habitable zone around those stars and numbers of planets in CHZ (Circumstellar Habitable Zone) (C)
4. Habitable planets for Carbon based life forms (V)
5. Habitable planets for Non-Carbon based life forms (V)
6. Identification of existing life forms on that planet (V)

But without going into the calculations we can classify the alien life forms on a planet into few categories. On an arbitrary planet depending on the intelligence and the understanding of fundamental forces of nature the alien life forms can be divided into five categories.

Type-I

Early evolving organisms: Organisms on the planets are mostly unicellular and simple multicellular organism.

Type-II

Lower intelligence organisms: Organisms on the planets are complex multicellular organisms, with a developed neural structure or brain, but have lower cognition capability or understanding of the surrounding.

Type-III

Intelligent organisms: Organisms on the planets are complex multicellular organisms, with a well-developed brain, intelligent enough to understand the processes of nature around them. They can understand the fundamental forces of nature.

Type-IV

Advanced Civilizations: This is the civilization 1000 years' ahead of current human civilization. Intelligent species on the planet understands the fundamental forces of nature and controls them, consumes all the natural resources on the planet and neighbouring planets.

Type-V

Colonists: At last the advanced civilization after consuming all the natural resources of their solar system and star reaches a stage, where they travel to other solar systems and stars and assimilate their resources and energy for their own existence and growth.

Chapter-36

Future Terraforming Missions

Current and future space missions will decide the fate of human habitability on solar and extra solar planets. The journey which once started with landing on Moon will take us far beyond imaginations of human mind. Now we are collecting as much information as we can about our nearest Terraformable planets Mars and Venus. There are few other candidates like Europa and Callisto moons of the planet Jupiter and Titan a moon of Saturn in our solar system.

The next focus of ours should be spreading the seed of life in extra solar planets. May be in our journey we will find evolved or primitive life forms in much different environmental condition than on earth. A planet uninhabitable for carbon based life forms may be habitable for life forms of different chemical composition. In such case careful considerations are to be made before interfering in the fate of alien life forms.

Voluminous amount of research is being carried out in the field of space and planetary science by different countries and organizations. But for extraordinary goals to achieve the whole world will have to work together. Terraforming requires unlimited amount of resources, man power and energy. So instead of separate space research organizations of every country there should be one International Space and Planetary Research Organization.

Terraforming should be studied as a separate branch of space science, as it involves voluminous amount of information and analysis. To Terraform a planet we need the detail Geological, Atmospheric and Environmental conditions of the planet. Only after knowing every aspect of the planetary dynamics we can move ahead. Much information can be gathers by studying our own planet and nearest neighbours in solar system.

There are many ways of Terraforming a planet after examining if it is fit for the same. But first the planets should be studies for successful Terraforming. Mercury and Venus along with all other planets and satellites of our solar system can provide us with valuable information for future analysis. Lithosphere, hydrosphere and atmosphere of each planet contain valuable information for understanding extra solar planets.

Future of mankind is to explore and understand the universe. In which Terraforming will play an important tool. We will travel to distant Galaxies and Solar systems, by using the knowledge of Terraforming we will be able to create habitable worlds for human civilization and save it when nature turns against us.

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